MATERIALS & METHODS

THE METALWORKING INDUSTRIES' ENGINEERING MAGAZINE

COPPER-BASE POWDER METALLURGY PARTS
A PRACTICAL APPROACH TO COLD TREATMENT OF STEEL
PRECISION CAST FINNED CYLINDERS
DRYING INDUSTRIAL FINISHES ON METALS
A NEW RADAR TRANSFORMER STEEL
FABRICATING SHEET METAL PARTS FOR JET ENGINES
PATTERNS MADE FROM CAST PLASTICS
MAGNESIUM IN ELECTRICAL BATTERIES

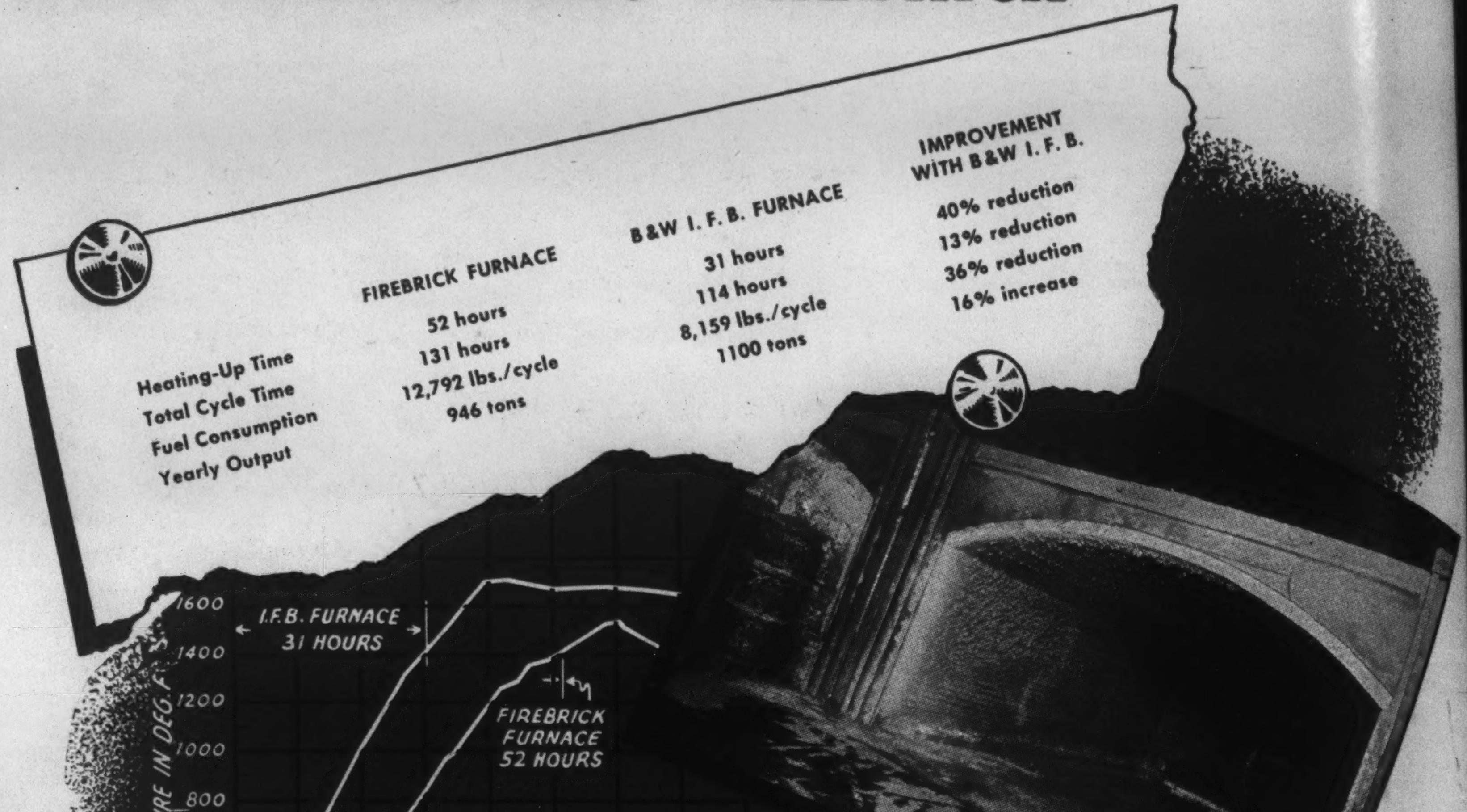
NICKEL AND HIGH-NICKEL ALLOYS

MATERIALS & METHODS Manual No. 21

ECEMBE

Annealing Furnace Tests Show Substantial Savings with

B&W INSULATING FIREBRICK



	FIREBRICK FURNACE	B&W I. F. B. FURNACE	IMPROVEMENT WITH B&W I. F. B.
Heating-Up Time	52 hours	31 hours	40% reduction
Total Cycle Time	131 hours	114 hours	13% reduction
Fuel Consumption	12,792 lbs./cycle	8,159 lbs./cycle	36% reduction
Yearly Output	946 tons	1100 tons	16% increase

During 1945, The Federal Malleable Company ran comparative tests to determine the most efficient refractory for their annealing furnaces. Two furnaces, having identical inside dimensions and duplicate conditions of loading and firing, were tested. Regular first-quality firebrick was used in one furnace—B&W Insulating Firebrick in the other.

The above tabulation shows the results of using B&W I. F. B.—reduced heating-up time, less cycle time, lower fuel consumption and increased production. Equally important, Federal Malleable points out that with B&W I. F. B. they can produce better castings, since they can duplicate the firing period by better control.

This case history is typical of the savings made possible by the use of B&W I. F. B. Similar results are being obtained in all types of steel processing furnaces such as annealing, stress relieving, normalizing, and heat treating.

Throughout the country, B&W Refractory Engineers are helping to guide progressive industries to more profitable production. For more detailed information on how you can increase the efficiency and economy of your furnaces—consult your local B&W Representative.

R-262

B&W

Water-Tube Boilers, for Stationary Power Plants, for Marine Service . . . Water-Cooled Furnaces . . . Superheaters . . . Economizers . . . Air Heaters . . . Pulverized-Coal Equipment . . . Chain-Grate Stokers . . . Oil, Gas and Multifuel Burners . . . Seamless and Welded Tubes and Pipe . . . Refractories . . . Process Equipment.

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MATERIALS & METHODS

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Covering recent developments in engineering materials and processing methods

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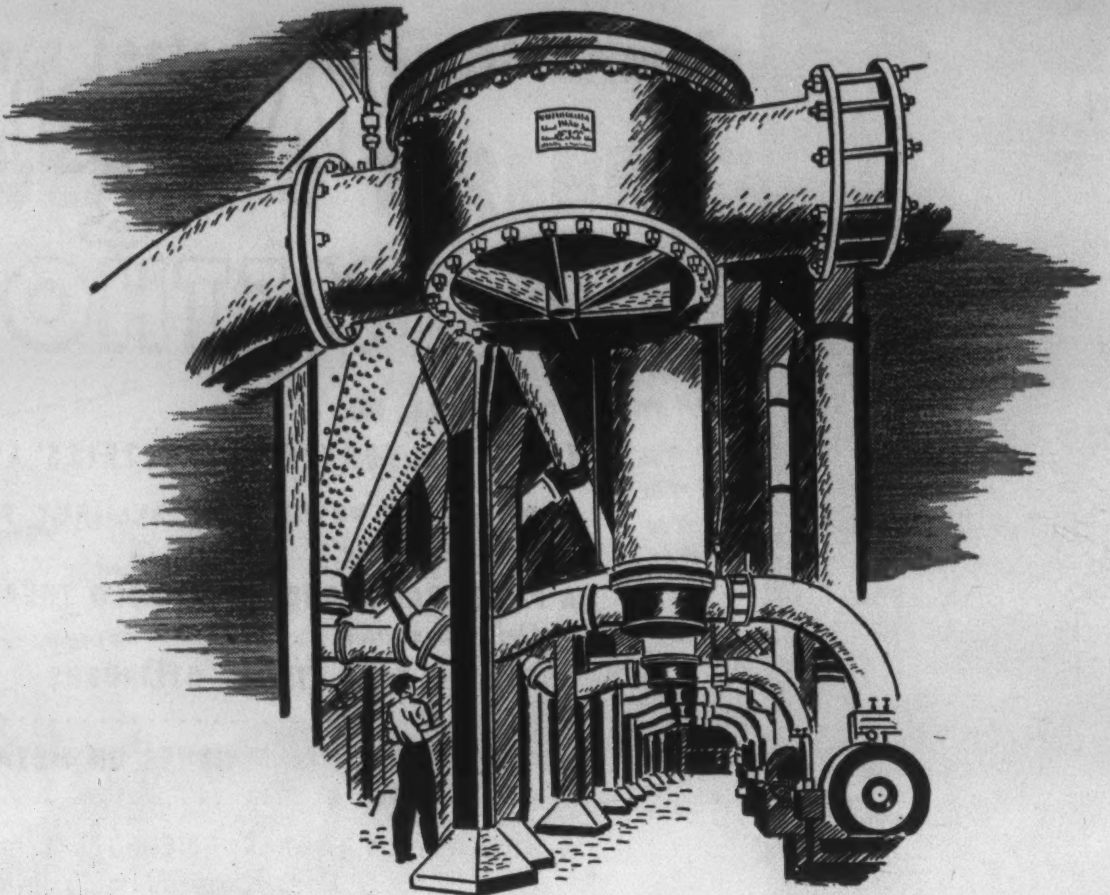

RESISTS ACID ATTACK

Stainless Steel Means Longer Life for Processing Equipment

This equipment is used in a process which involves the continual circulation of a corrosive sulphite liquor. Paper mill men say the process would not be possible without the use of stainless steel for pipes, valves, and fittings. These installations have thoroughly demonstrated the effective resistance of the metal to the corrosion encountered in the industry. Stainless steel is also extensively used in the chemical and petroleum industries, where again corrosion is the enemy of low maintenance costs and uninterrupted production.

If you are interested in other new uses of stainless and other alloy steels, ask to receive the monthly publication, ELECTROMET REVIEW. If you need information on the production, properties, or fabrication of these steels, write our Technical Service Department. While we do not make steel, we do produce the ferro-alloys which are used in its manufacture, and our engineers have accumulated a fund of information on the use of stainless steel in many industries.

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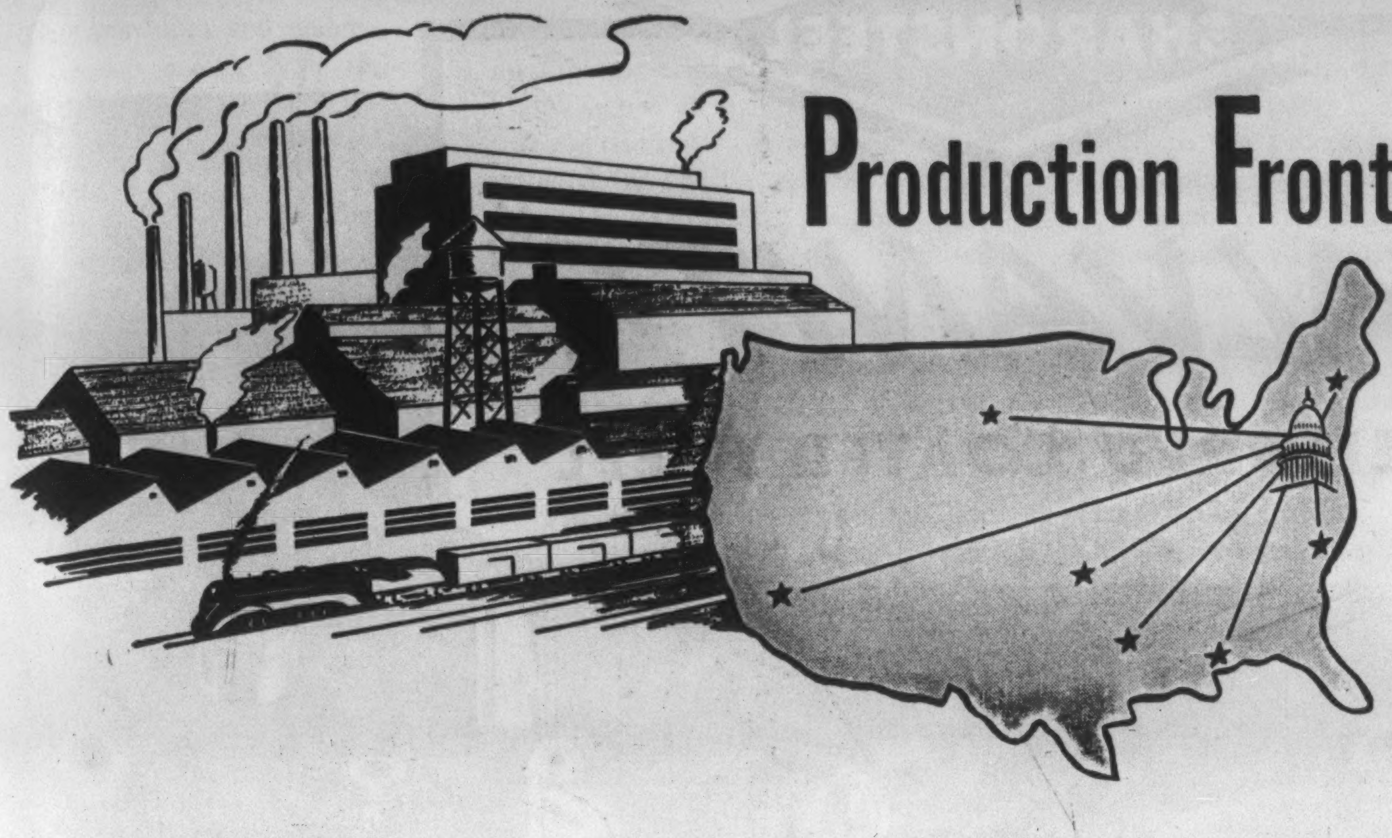
of Canada, Limited, Welland, Ontario

STAINLESS STEEL

BEAUTIFUL ENDURING STRONG TOUGH

Production Frontiers



Keep Talking Depression — Then You'll Have It

The favorite indoor sport just now is predicting the general future economic trend for 1947. The many printed predictions from the "professionals," semi-pros and amateurs come a dime a dozen. A common question is: "When will the depression set in?" Somehow the impression is rife that, as night follows day, a period of economic distress is due in months counted on fingers of two hands.

Perhaps the most sensible view is that from the sensible Committee for Economic Development, which said in early November: "Today the mere notion that a major depression is inevitable has to be attacked. It is no more inevitable than the idea that we had to have mass unemployment after V-J Day. We can have a depression if we drift into it or do enough foolish things. On the other hand, we can think and act to stop it before it gets started."

Impressive is the survey conducted among a list of 72 non-government economists by the F. W. Dodge Corp. Many of these economists have a national reputation, such as the late Brig.-Gen. Leonard P. Ayres of Cleveland, who died shortly after the survey was taken. Of 50 who expect that a downswing in commodity prices will take place before the end of 1947, only one expects such business recession to assume serious proportions. Twenty-three characterize the expected coming recession as "mild", 24 of them as "moderately serious." Twenty-eight do not expect serious unemployment. Only 12 expect serious unemployment. About half predict buyer's strikes, two-thirds look for inventory troubles and reduced business profits.

A composite of the views of these economists, connected with business corporations, financial institutions, universities and economic research organizations, is as follows: Consumer goods will reach a price peak and turn down in the spring of 1947; building materials around the middle of next year, other durable goods in the second half of 1947. Two-thirds believe that the downswing duration will be under 12 months in consumer goods prices; 60%, less than 12 months in building materials prices, and 50% under 12 months in durable goods other than building materials.

As a general conclusion, the majority consider that commodity price inflation has very nearly run its course, the minority expecting it to run into 1948 or beyond.

Our System Stood Up Under Adversity

Interesting thoughts along somewhat different lines are those of Dr. Zay Jeffries, noted metallurgist and observer of the times. He told Lehigh University graduates that "we have better proof today of the fundamental soundness of our industrial structure than at any time in history." He went on to say that the American economic system stands even stronger and sounder than even optimists predicted. "American business has been subjected to one unsound measure after another. It has been prosecuted, smeared, and heavily taxed. Yet in war it performed the greatest engineering and production miracles of all time. In many ways it strengthened itself through adversity. But American business needs a friendly and helpful government that believes in the American system and one that umpires rather than manages."

As to present day thoughts on labor-management relations, James F. Lincoln, president of the Cleveland company bearing his name, said recently: "If all people refused to do their duty to the public as has been the case with union labor recently, the human race would disappear. Suppose the doctors and nurses and ministers and industrialists should follow this union labor pattern—and they could easily—what would occur? Health and security would disappear. Suppose the mothers of this country should follow the union pattern of no responsibility, five-day week, vacations with pay, health-fund and improved working conditions. Home and family would be impossible."

But on another occasion Mr. Lincoln was much more tolerant towards labor. In fact, sympathetic. He said: "The blunt truth is that much of manufacturing progress has

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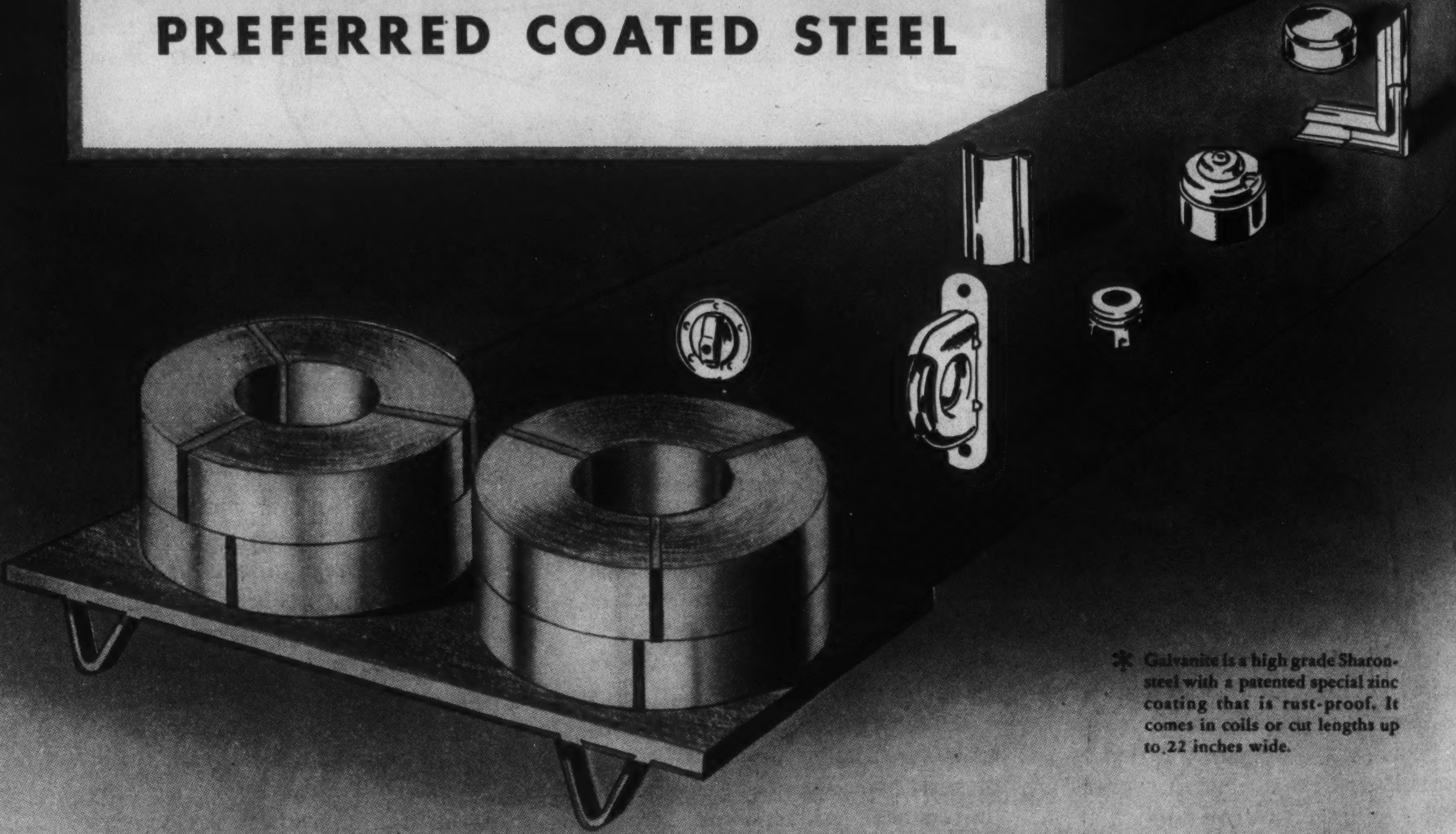

* Galvanite is a high grade Sharon-steel with a patented special zinc coating that is rust-proof. It comes in coils or cut lengths up to 22 inches wide.

The Lengthening Shadow of Quality!

The goodness of Galvanite-coated Sharon-steel can be measured by the ever-increasing number of quality products that come within its "lengthening shadow."

It has become a preferred coated steel with fabricators *—because of what it does.*

Galvanite strip is weather-resisting, non-rusting, suitable for deep drawing and forming. There's no peeling, flaking, or powdering of coating after difficult formation. The surface lends itself to painting.

Sharon also produces galvanized, tin-coated, terne-coated and special alloy coated strip steels of fine quality.

For full information about what Sharon coated products will do for you, write to the nearest Sharon field office, or to the company's home office today.

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come from machines and gadgets as applied by top management rather than from development of men. Man is the source of more progress than any inanimate machine or other object. To draw out those abilities will require a fundamental change in management responsibilities. The average worker has learned from bitter experience that when work is slack he is tossed out in the street, often with little thought for his future. No wonder then that he considers restriction of output necessary to stretch available work and the tenure of his job."

That Golden Goose Again

Expert economists have been predicting that John L. Lewis will be "given so much rope that he will hang himself." In other words, coal will become such an expensive fuel because of constantly rising labor costs that consumers will turn to other fuels.

We recall that in our early shaving days one safety razor blade was good for 30 shaves. Either the blades became worse and/or our whiskers got tougher till the life of the blades steadily decreased to about one blade per shave and not a very good shave at that. So we turned to an alternate means of shaving and have remained there since over a span of 20 years. We acquired straight edge razors, the barber's kind, and do our own honing.

It is either fiction or fact that automobile makers purposely make automobile parts inferior because of the added business of supplying new parts. The average motorist has had experience with replacing corroded mufflers.

If there is anything that makes us want to take vitriolic pen in hand or mount scarce soap boxes on street corners to protest against—it is the deliberate manufacture of short-lived parts and end products just to increase the replacement business. It will be our contention to our dying day that the manufacturer who strives to make his product as long-lived as possible (within reason—no use in having a component part have double or triple the life of the whole assembly) will be the most successful manufacturer. Suppose he does saturate his market with things that don't wear out. He can turn to the manufacture of other long-lived items, the sale of which should be tremendous because of the reputation he has acquired in making a superior original product.

Which is all by way of leading up to electric bulbs. A survey was conducted by Dr. George W. Stocking and Dr. Myron W. Watkins, under the sponsorship of the Twentieth Century Fund, on the international cartel in light bulbs. One of the objects of the cartel, states these investigators, was: "Limitations of, and on occasion a reduction in, the life of lamps, to increase sales."

However, in justice to the bulb manufacturers there may be some phase to the case that does not meet the eye. For example, the investigators concede that the most efficient lamp is not the longest-lived one (thus, the skyrocket makes perhaps the most brilliant display on July 4, but does not last as long as the more conservative pinwheel). Indeed, the report admitted the possibility that the more efficient though shorter-lived bulbs might actually give the consumer more and better illumination for his lighting dollar—although the purpose in making the short-lived bulbs clearly appeared to be to increase sales of bulbs.

A-1 METAL-STAMPING CO.
Edgar Allen Jr.

"Down once more, O'Rourke, the collar isn't ironed yet!"

Stocking and Watkins quote a letter from one bulb-making official to another, as follows:

"We are being pushed very hard by competition. Most of these lamps are at somewhat lower efficiency than ours and inherently have a longer life. It is very difficult to convince the typical consumer that efficiency of the lamp is the important thing. He is prone to judge quality by life alone. We realize that the constant reduction of lamp life that we have been in the process of carrying on has kept the volume of business up, but cannot refrain from giving a word of warning and a suggestion that it is about time to call a halt on this in view of the competitive situation."

Our own suggestion is that research departments should work on a 24-hr. per day schedule until they have combined ultra-efficient with ultra-long lasting product.

We believe that MATERIALS & METHODS will not be considered too idealistic if, in the little preaching that it does, it urges striving for perfection in searching always for the best materials for any given item of use and the best methods for fabricating those items. We believe that when this has been accomplished, sales and profits will take care of themselves.

We Learn Much About Magnesium

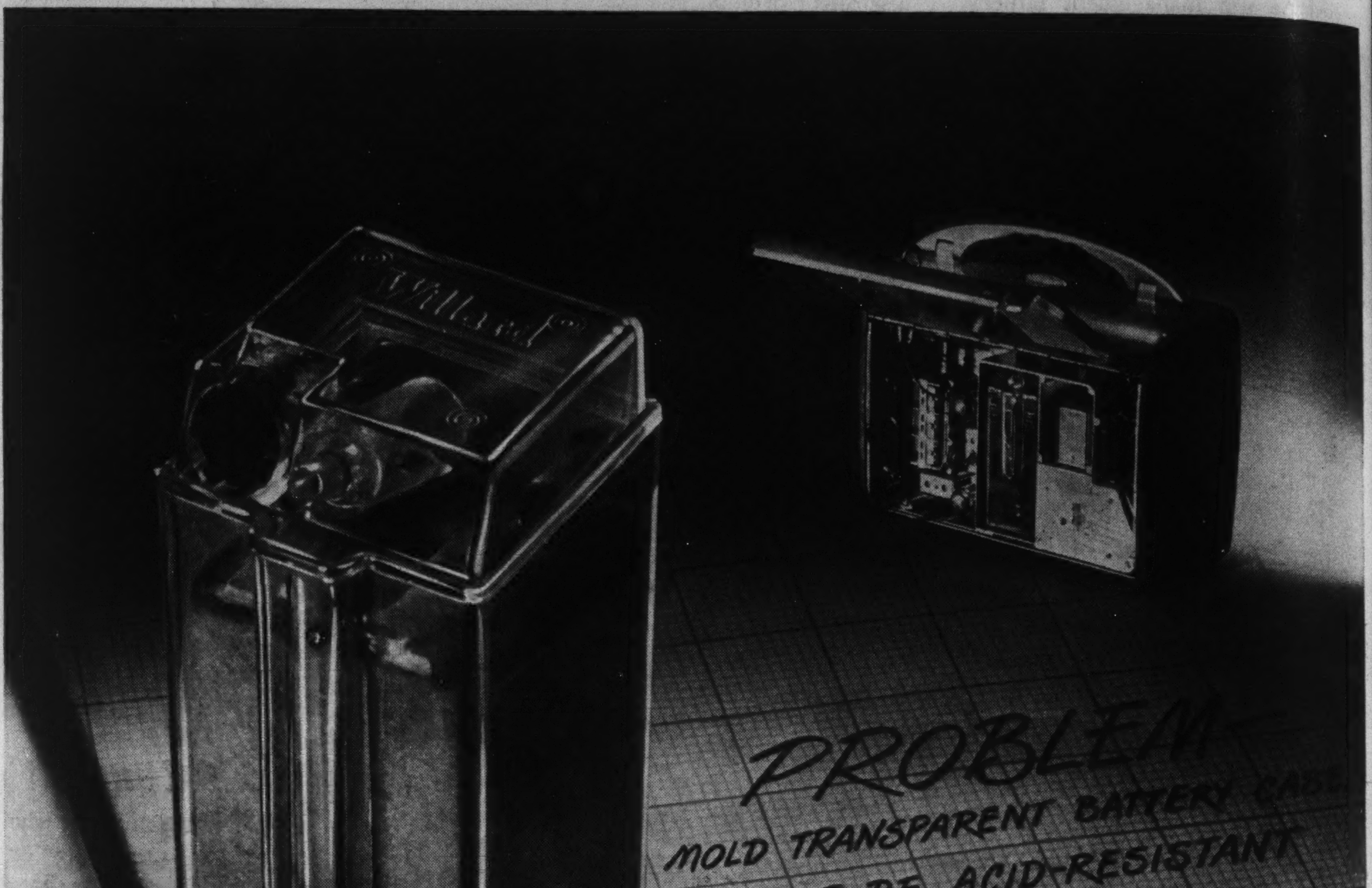
There are 54 companies in the United States now producing or fabricating magnesium against three companies in 1939. At least 95% of the companies who entered the magnesium field during the war have converted to peacetime manufacture. Output of magnesium here rose from 3,350 tons in 1939 to a peak of 184,078 tons in 1943, remaining at this level during 1944 and 1945.

These and other interesting facts we learned at the third annual meeting of the Magnesium Assn. and First International Magnesium Congress at New York in early October. Eleven foreign magnesium men attended. An evidence of the success of the advertising and promotion program for magnesium is the statement of an executive of a nationally-known department store that magnesium is second only to nylon as a "magic" sales word.

The exhibits were at least twice as numerous as the preceding year, reminding one that the magnesium industry is now truly converted to peace. There were many sample components of magnesium, often complex in design, such as an oil separator device for de-icing equipment of an airplane, as intricate as a Rube Goldberg device. Despite its complexity, it is both lighter and cheaper than aluminum.

Among the spectacular exhibits

• ENGINEERED AND MOLDED AT NO. 1 PLASTICS AVENUE



A clear case for plastics

• Here's the battery that speaks for itself. Its transparent case lets you see the liquid-level at a glance . . . and a hydrometer, molded into the case, tells the charge. It's the storage battery for the G-E self-charging portable radio.

During the war, plastics battery cases proved their value in walkie-talkies, storm lamps, and other military items. For this Willard storage battery, the leakproof, acid-resistant case is injection-molded to exacting specifications by General Electric. The material is polystyrene—lighter than glass and stronger than hard rubber. G. E.'s *complete* plastics service covers every step in the design and manufacture of plastics products.

Have you a plastics product to design? Consult General Electric—world's largest manufacturer of finished plastics products. We'll be glad to send you a new booklet, "What Are Plastics?" Write Plastics Divisions, Chemical Department, General Electric Company, 1 Plastics Avenue, Pittsfield, Mass.

G-E Complete Service—Everything in Plastics

BACKED BY 52 YEARS OF EXPERIENCE. We've been designing and manufacturing plastics products ever since 1894. G-E Research works continually to develop new materials, new processes, new applications.

NO. 1 PLASTICS AVENUE—complete plastics service—engineering, design and mold-making. Our own industrial designers and engineers, working together, create plastics parts that are both scientifically sound and good-looking. Our own toolrooms are manned by skilled craftsmen—average precision mold experience, 12 years.

ALL TYPES OF PLASTICS. Facilities for compression, injection, transfer and cold molding . . . for both high and low pressure laminating . . . for fabricating. And G-E Quality Control —a byword in industry—means as many as 160 inspections and analyses for a single plastic part.

EVERYTHING IN Plastics

GENERAL ELECTRIC

CD 46-A18

GENERAL ELECTRIC PLASTICS FACTORIES ARE LOCATED AT SCRANTON, PA., MERIDEN, CONN.
FORT WAYNE, IND., TAUNTON, WEST LYNN, AND PITTSFIELD, MASS.

were canoes and outboard motorboats, ladders, a truck, and a piano, with magnesium working parts, played by a gal in a red dress. (We fear that many had no ear for music that day.)

Luncheon talks and technical sessions were of unusually high calibre. One can always count on Dr. J. D. Hanawalt of Dow to tell something worth while. One of his themes is that for most applications a component or finished product must have certain required physicals which no one material can fulfill perfectly. However, one must choose the material which can best satisfy the group of requirements. In aircraft wheels the main needs are lightness, toughness and fatigue strength. The optimum combination is best served by magnesium.

A ski must have rigidity, resilience and lightness. Without rigidity the far ends of the ski would do no work. When you slide over a hollow in the snow, the skiis must be resilient enough to return to their original shape, otherwise they'd look like two chair rockers. Wood and magnesium are the "naturals" for skiis, both having a good combination of lightness, rigidity and resilience. But magnesium is stronger, has structural uniformity and freedom from susceptibility to temperature and humidity changes. There are many places in textile machinery where "mag" has replaced wood for these reasons. Piano parts in magnesium afford another example. Dimensional accuracy is another light metal attribute.

Dr. Hanawalt dwelt on resistance to permanent deformation or denting of a panel. He exhibited a steel, alongside a magnesium panel, both of which had been subjected to impact. (The fellow sitting next to us whispered: "He's taken the strongest magnesium and presents it alongside the most inferior steel". We ignored this impostor, so let's give heed again to Dr. Hanawalt.) The steel was a pretty sorry specimen but the magnesium had taken it on the chin admirably.

Dr. Hanawalt commented: "The magnesium panel is twice the thickness of the steel but less than half the weight. The magnesium is stiffer and suffers less damage from the same impact blow." The doctor seemed fair. He admitted all is not "beer and skittles". For instance, where lightness plus tensile or compression yield strength in axial loading are required, then aluminum alloys of the 75 S type are indicated.

As usual, there was a certain amount of humor and levity as an antidote against too severe a seriousness. Dr. Hanawalt himself was a bit of a clown when he held up a magnesium chair and kept it aloft as he continued his discourse, "apparently" oblivious toward his burden. After several minutes he suddenly "realized" that burden and, with great "surprise", set it down—actor that he is!

It brought smiles, too, when the anecdote was told about the voluminous reports to the Government that Dow was required to fill out. One particularly tedious questionnaire finally arrived at the question: "State source of supply of your raw material". The weary Dow man wrote: "Ocean". In three weeks a letter was received from Washington: "As to question No. 76, page 18, please be more specific."

Another laugh was occasioned when Ralph M. Heintz of Jack and Heintz described what people called the early magnesium die castings: "Case-hardened sawdust". (We learned that magnesium die castings are the cheapest as to machining costs of several: Aluminum die castings machining is 25% higher in costs; bronze, 35%; and cast iron, 50% higher.)

We always like to think that behind all these wonderful new materials and processes there are humans—the more human, the better. And speaking of humans, Edward S. Christiansen, retiring president of the Magnesium Assn., said this about a fellow officer: "The country has been made magnesium-conscious in no small degree due to the efficient activity of our genial and able executive vice-president, Ted Atkins. Wherever he goes, he exudes unbounded confidence and infectious enthusiasm for the future of the magnesium industry". (One likes to see credit given where well-deserved!)

HCl

We gleaned the following whimsy from a recent issue of the *"SKF Sphere"*, house organ of SKF Industries.

Someone had wired a government bureau asking whether hydrochloric acid could be used to clean a given type of bearing. The answer was: "Uncertainties of reactive processes make use of hydrochloric acid undesirable where alkalinity is involved."

The inquirer wrote back, thanking the bureau for the advice, saying that he would use hydrochloric acid. The bureau wired him: "Regrettable decision involves uncertainties. Hydrochloric will produce submuriate invalidating reactions."

Again the man wrote thanking them for their advice, saying that he was glad to know that hydrochloric acid was all right. This time the bureau wired in plain English:

"Hydrochloric acid," said the telegram, "will eat hell out of your bearings."

Six Thousand at Aberdeen

Six thousand members of the Army Ordnance Association treked to Aberdeen Proving Ground early in October to attend the 28th annual meeting. There we witnessed a demonstration of this country's latest developments in fighting equipment.

Super Heavy Tank, T28—This armored monster weighing 100 tons is the heaviest vehicle ever built for the Ordnance Department. It packs a 105-mm. gun and its heaviest armor is over a foot thick. A unique feature is its two sets of tracks on each side. Demonstrated along with this behemoth was the 100-ton tank recovery unit, T67. This trailer unit, with the 100-ton tank astride its back, pulled away without any noticeable exertion.

Self-Propelled 240-mm. Howitzer, T92—This is the largest self-propelled artillery weapon built to date. It has excellent mobility and can be emplaced ready for firing within 5 min.

Heavy Tank Transporter, T8—Like the new Studebaker, you can't tell whether this vehicle is coming or going. It drives from both ends and the operators synchronize their gear shifting by intercommunication between the two cabs.

105-mm. Recoilless Rifle, T19—Here is a weapon, the equivalent of a 105-mm. field artillery piece, that becomes a weapon for the foot soldier. It is designed so that powder gases escape to the rear to just balance the recoil action. Thus, all the weight of a recoil mechanism is saved.

News of

Engineers — Companies — Societies

Engineers

Dr. John Johnston retired as director of the research laboratory of the U. S. Steel Corp. of Delaware, November 1, being succeeded by *Dr. J. B. Austin,* assistant director, who studied physical chemistry under Dr. Johnston at Yale University. The U. S. Steel laboratory was established by Dr. Johnston at Kearny, N. J., late in 1928. He was educated in Great Britain, Germany and the United States. He was a member of the War Metallurgy Committee. Dr. Austin was graduated from Lehigh University and received a Ph.D. from Yale.

Dr. Frederick J. Winsor, formerly research assistant in the welding laboratory at Rensselaer Polytechnic Institute, has become research metallurgist with the Armour Research Foundation, Chicago.

Herbert C. Geittmann has become plant engineer with the Phosphor Bronze Smelting Co. He was graduated from University of Wisconsin in 1938, was ordnance officer in the Army, and was special sales engineer for the Standard Steel Works Div., Baldwin Locomotive Works.

Howard C. Cross, high temperature alloy specialist at Battelle Memorial Institute, is visiting research laboratories in England, observing test procedures in heat-resisting alloys. *John A. Vanecho,* formerly lieutenant (j.g.) in the Navy, has joined Battelle for research in high temperature alloys. Prior to 1944 he was at the S. Chicago plant of the Carnegie-Illinois Steel Corp. *Roland B. Fischer* has joined Battelle to do research in physical metallurgy, having been with the American Smelting & Refining Co. at El Paso, Tex., and a lieutenant in the Army Engineers. *Charles E. Smith, Jr.* has affiliated with Battelle for research in production engineering, having been with Sylvania Electric Products Co. as design engineer.

L. G. Tingwall, Sr., has joined Intercontinental Engineers, Inc., Chicago, as consultant, being a plant design engineer and having been with Revere Copper & Brass, Inc.

Theodore K. Davis has been made works manager of Micro-Ferrocart Products Div., Maguire Industries, Inc., Stamford, Conn., maker of powdered iron and copper alloys. Associated with him are *John Polenetz,* chief engineer, *E. Raymond Engstrand,* chief metallurgist, and *Kenneth M. Gleszer,* general sales manager.

S. J. Jazwinski, English metallurgist, has become chief metallurgist, Barium Steel Corp., New York. He is a graduate of Warsaw University, Poland, and has authored books and technical articles on foundry and steel-making subjects.

William A. MacCrehan, Jr. has become assistant professor of administration engineering and director of the Gage Laboratory at New York University. He has specialized in quality control, part of the time at the General Electric Lynn plant.

Louis V. Sutton, Jr. has become methods engineer, Edwards Co., Sanford, N. C., maker of machines and parts. He received his B. S. degree in chemistry from the University of North Carolina and has served with the Navy.

C. R. Dobson has been elected vice president in charge of operation of seven manufacturing plants of H. K. Porter Co., Inc., having been chief industrial engineer, Jones & Laughlin Steel Corp.

Herbert C. Graves, Jr. has been appointed chief engineer, Gibson Electric Co., Pittsburgh, maker of electrical contacts. Previously he was engineering manager for I-T-E Circuit Breaker Co. He has been granted 20 patents in the United States and others abroad.

Wallace C. Husted, vice president in charge of all activities of Chase Brass & Copper Co. in the Cleveland area, has been transferred to Waterbury, Conn., in charge of organization and plant operations under *Richard D. Ely,* vice president in charge of production. *John S. Coe* succeeds Mr. Husted in Cleveland and becomes a vice president.

Chester H. Kimmel has been appointed manager of the camshaft and crankcase divisions, Ohio Crankshaft Co., while *Morgan R. Kavanagh* is new factory manager, those divisions. Mr. Kimmel was with Packard Motor Co. for several years, while Mr. Kavanagh was with the Oliver Iron & Steel Corp.

C. M. Taylor has become executive vice president of the Lincoln Electric Co., having been with the company since 1916, in charge of time study and methods, having been superintendent and vice president in charge of sales.

Ben L. Wise has become production engineer with National Electric Welding Machines Co., Bay City, Mich., having been assistant general manager, Federal Machine & Welder Co., Warren, Ohio.

Robert C. Singleton has become technical advisor to Nelson Sales Corp., Lorain, Ohio, having at one time been metallurgist with Joshua Hendy Iron Works and later senior metallurgical engineer for Nelson Specialty Welding Equipment Corp.

J. R. Barefoot, formerly plant engineer, has become executive assistant to the executive vice president, Federal Machine & Welder Co. He will coordinate production among several plants.

Bruce Bevelheimer is now assistant to the vice president, Furnace Engineers, Inc., Pittsburgh, industrial furnace designers, having been associated with the steel industry as fuel engineer since 1924. He has been with the Bethlehem and Algoma companies.

Companies

The *Kaiser & Frazer Parts Corp.* is now producing pig iron from a 500-ton blast furnace at Youngstown, Ohio, leased from the *Struthers Iron & Steel Co.* for three years to break the materials bottleneck. The iron will be supplied to small foundries that make gray iron castings for the automobile company.

For the first time in the history of steel making the vivid changes occurring during a heat within the walls of an electric arc furnace now may be seen in actual colors by motion picture, according to *Allegheny Ludlum Steel Corp.,* which sponsors a 15-min. film on "Melting of Huron Die Steel." It is available free of charge to technical societies and lay audiences. The film was shot through an open furnace door by a camera 8 ft. away, utilizing a telephoto lens. It was so hot the camera man shot sequences of only 25 to 30 sec. at a time, but the film appears a continuous scene.

The *General Electric Co.* will start construction this year of a $20,000,000 factory for manufacture of steam turbines and electric generators at Schenectady. The building will be nearly a quarter mile long

(Continued on page 1586)

Meetings and Expositions

INSTITUTE OF THE AERONAUTICAL SCIENCES, Wright Brothers Lecture. Washington, D. C. Dec. 17, 1946.

SOCIETY OF AUTOMOTIVE ENGINEERS, annual meeting. Detroit, Mich. Jan. 6-10, 1947.

MATERIALS HANDLING EXPOSITION, Cleveland, Ohio. Jan. 14-17, 1947.

SOCIETY OF THE PLASTICS INDUSTRY, Low-Pressure Division meeting. Chicago, Ill. Jan. 23-26, 1947.

SOCIETY OF PLASTICS ENGINEERS, annual plastics show and convention. Chicago, Ill. Jan. 25-31, 1947.

INSTITUTE OF THE AERONAUTICAL SCIENCES, annual meeting. New York, N. Y. Jan. 27-30, 1947.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, winter meeting. New York, N. Y. Jan. 27-31, 1947.

AMERICAN SOCIETY OF HEATING & VENTILATING ENGINEERS, annual meeting. Cleveland, Ohio. Jan. 27-31, 1947.

AN
EDITORIAL

The Expediter

Once upon a time an expediter was a man in the plant who followed orders through production and saw that no obstacles were allowed to delay their completion. He was, in short, someone who got things done quickly.

But the "expediter" of today is simply someone who gets things—period. He is an alert, resourceful and persistent scout who scours the field for materials and equipment that his company badly needs to start production or to keep it moving. And his very existence is a symbol of the strange straits in which industry now finds itself—tremendous demand pressure from its customers for almost every conceivable kind of product, on one hand, and a crippling shortage of raw materials, component equipment and full-time labor on the other. The most heartbreaking aftermath of this muddle would be its degeneration into the 1947 depression now being so freely predicted by many observers.

This country and its manufacturers need more than expediters to solve the production problems that confront us all. Expediters merely channel available supplies into the more aggressive places. What we desperately need today is a complete, wholehearted and cooperative effort by everyone concerned to boost the *total* volume of production, lower the *general* level of prices and place this *entire* nation and its workers back on the track to prosperity and happiness. We need less selfish grabbing and more teamwork, fewer expediters and more collaborators.

Those of us whose "bread and butter" is the selecting and processing of engineering materials can be among the world's best collaborators of this type, if we will. We can be careful to avoid hoarding, to order no more raw materials than we would under sound business practice in normal times. We can build into our products those materials and forms that we know are more generally available and avoid those that are currently scarce. We can segregate our scrap metals, and then return them to the metal manufacturing industry via regular waste-industry channels, rather than make tie-in sales with individual metal producers.

Those of us who are in charge of production can be even smarter than we have been about playing fair with labor, more careful to explain to workers the simple economic facts of running an individual business as well as supporting a National economy.

And since many of us are in the key positions of designing and manufacturing *to meet a price*, we must extend our ingenuity even farther than we have in devising methods and applying materials to bring down our manufacturing costs. The cost of labor is not going down for a long time. Therefore the only ways in which prices can be reduced are through reductions in production costs and/or in profits. The extent to which we can achieve the former through technical means will directly influence the latter.

It's up to us — all of us! What are we, expediters or collaborators?

FRED P. PETERS

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RYERSON STEEL

Editorial Comment

Continuous Rolling of Magnesium

What hinders the development of any a new product is the slowness ith which its sponsors get down to uly mass production methods. No onder wooden pegs were used so exnsively by carpenters a century ago! on nails were hand-made, and it was ot until the steel wire nail was manuctured by automatic machinery that etal fasteners became almost uniersal not so very many years ago.

And thus could one trace the history hundreds of mass-produced and niversally-used products today. Which by way of introduction of what ay be happening to magnesium. At e third annual convention of the agnesium Association, the trade asciation for that metal, we were shown hotographs on a screen of magnesium eing rolled down into sheets on a ntinuous steel rolling mill in Great ritain, the demonstrator having been ajor C. J. P. Ball, chairman, Magnesm Elektron, Ltd., London. Just a few oments before the magnesium ingot n down the roller conveyor table, a eel ingot had passed in the same rection, implying that few, if any, anges had been made in the rolling ill adjustments.

Then at the same convention Dr. D. Hanawalt of Dow gave more tails. (We don't know whether he as referring to the British experiment to a similar one in the United ates.) He said that the ease of rolling agnesium was demonstrated last sumer on a continuous strip steel mill. ast slabs of Dow FS alloy were put rough a reversing breakdown mill ith enough speed and power that the agnesium actually became hotter ther than cooling off while being lled from 7 in. down to 0.4 in. in 2 in. On the present conventional magsium rolling mill, the 200-lb. slabs e expensive to cast and scalp in the st place. The small slab is broken wn so slowly in the rolling mill and ndled so much that it cools off and ust be reheated several times.

But on this continuous steel mill it as passed on hot to the tandem mill, ming out and being coiled at 1200 per min. a moment later as 0.050- sheet. Aluminum has, of course, eady made the transition from small mill to continuous mill. Aluminum slabs, 2000 to 3000 lb. each, are rolled and coiled without hand labor.

So, when the demand for magnesium sheet has expanded sufficiently to justify it, the equipment is there to turn it out, and for considerably lower selling price than today.

—H.A.K.

Tailor-Made vs. Standardized Materials

In the field of industrial materials there is a constant tug-of-war between the desire of the designer and engineer for a highly specific material for each purpose or product — a tailor-made material, as it were — and the desire of the supplier to standardize his types, grades, and analyses into as few varieties as possible. As each desire is in line with logical evolution in industry, there seems to be little hope that either will be completely satisfied. The engineer selecting materials will find himself striving for any small advantage that can be obtained by even a slight change in a material that will better fit it for a specific application, and, when competition is restored, give his product a slight edge over others in the same field. On the other hand, the materials supplier is concerned with long runs to reduce his costs, with the broadest standardization possible to reduce his inventories, and with the widest specification limits to reduce his rejects.

At present there is no contest. The shortage of materials of most kinds is so great that buyers are willing to take almost anything in the market that will approximate their needs. As a case in point, a builder of small heating units recently began using sheet aluminum for an outside sheathing instead of the sheet steel formerly employed, not because he needed the special properties of the aluminum, but because aluminum was available and steel was not. This will change, and change radically, when the country is restored to sanity and the new competition in every field makes itself felt.

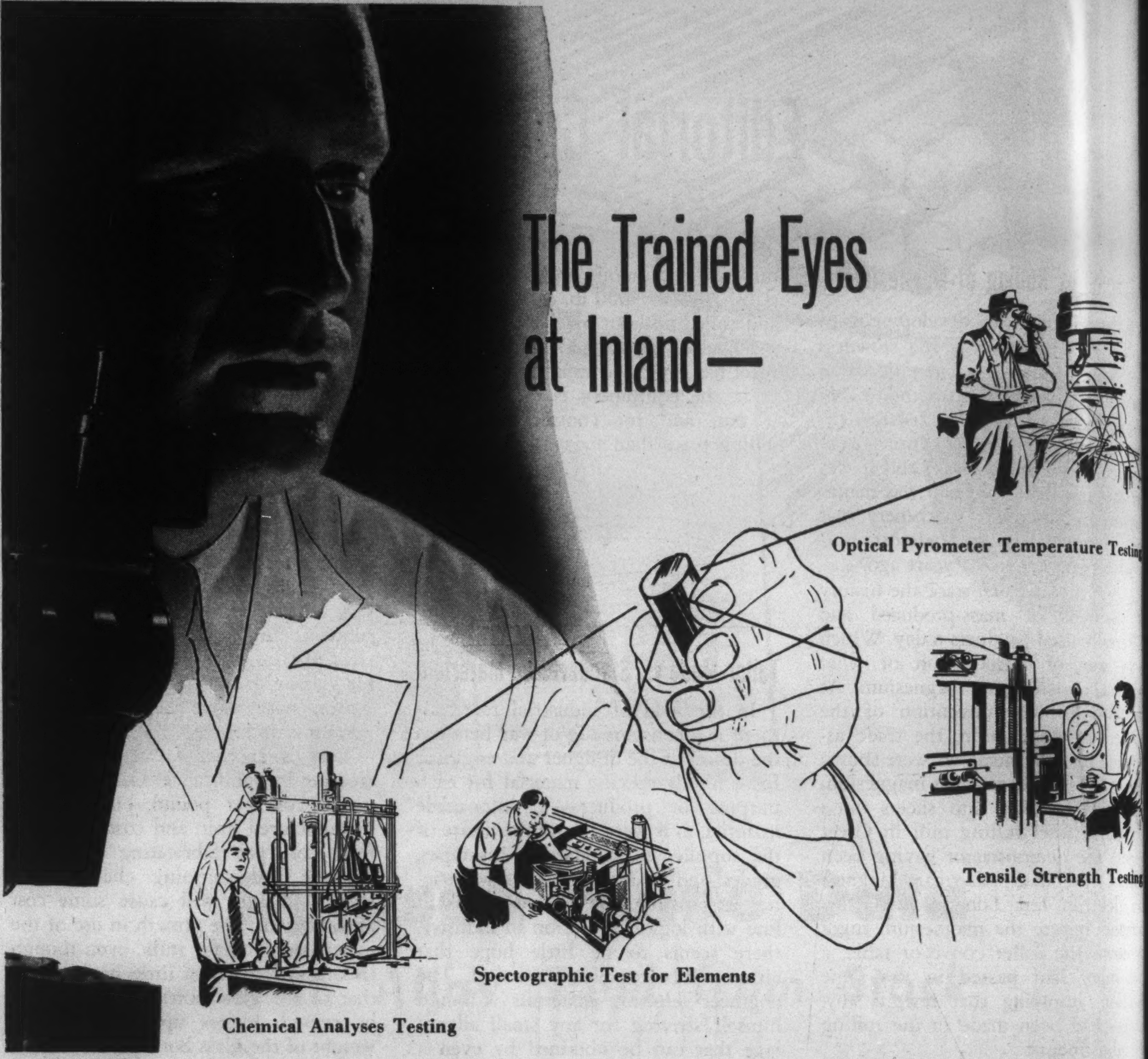
The problem for materials and process engineers promises to be amazingly complex. The physical properties alone are exceedingly intricate for any one material, and steadily becoming more so. Tensile strength, yield strength, compressive strength, flexural strength, stiffness, hardness, abrasion resistance, etc., have had added to them such "double-variable" evaluations as fatigue strength, in which loading and number of cycles are interdependent, or creep resistance, with time and temperature as variables. A great many new tests have been added, or have recently assumed added importance. As clear plastics offer competition to glass for glazing or optical purposes, for instance, haze value becomes an important criterion.

Cost is another factor that is increasing in significance. Cost no longer means cost per pound, but cost per manufactured unit, and cost per cubic foot, cost per fabricating operation, delivery and shipping charges, and storage charges will cause some cost reevaluation. The growth in use of the paper container for milk, even though its original cost is a little higher than that of the glass bottle and it cannot be reused, hinges upon the heavier weight of the glass bottle, the fact that the delivery vehicles can return empty when using the paper container, and the short life of the glass bottle.

When added to these factors are such imponderables as customer preference, sales appeal, eye appeal, and similar hurdles for the maker of consumer goods; the fabricating limitations of the various materials; uniformity of quality; steadiness of supply — surely the engineer can be pardoned if he seems overly insistent upon a slight variation of a certain standard analysis, or a slight narrowing of specified physicals. After all, if his particular product has performed slightly better with the changed analysis, or a material has been fabricated slightly faster, or better, when certain physicals were maintained, he has obtained that slight edge over competitive products that, in the days to come, might mean establishing leadership in the field. That critical evaluation and selection of materials from both the service and the processing standpoints is his job.

—K. R.

The Trained Eyes at Inland—


Optical Pyrometer Temperature Testin

Tensile Strength Testin

Spectographic Test for Elements

Chemical Analyses Testing

Every day, year in and year out, ton after ton of steel passes the scrutiny of Inland's "trained eyes" . . . Samples are gathered from all operations and subjected to exacting tests before the steel is permitted to be rolled into final form.

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Inland steelmakers working together closely, care fully on each individual order means *that* order wil "measure up" to every requirement when delivere

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INLAND
STEEL

MATERIALS
&
METHODS

DECEMBER 1946

Of these machine parts produced from bronze powder, several could have been produced in other ways, but all would have required considerable machining and would not be porous. (Courtesy: Amplex Div., Chrysler Corp.)

Copper-Base Powder Metallurgy Parts

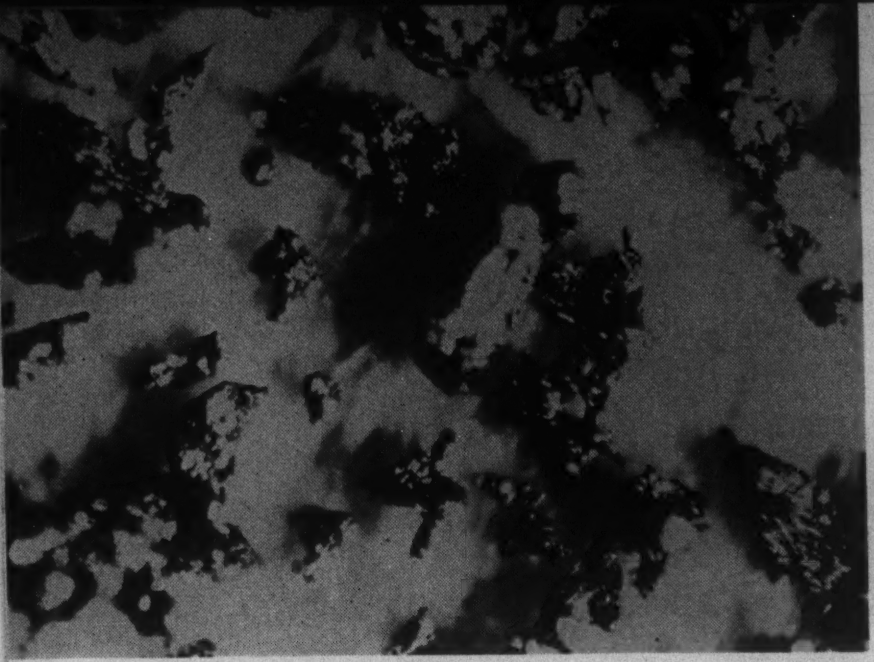
by HERBERT CHASE

WHILE MOST RECENT public attention has been focused upon developments in powder metallurgy centering around iron powders, equally interesting and important progress has been made in the production and use of parts made from copper-base powders.

In this group are included many brasses and bronzes, as well as pure copper. Until the present, 10% tin—90% copper bronze has been most widely used, principally for bearing applications. Now, with tin scarcities, other copper-base alloys that, except as to bearing characteristics, have properties close to those of the tin bronzes and are lower in cost are receiving considerable attention.

One of the last barriers to increased usage of brass powder metal parts has been removed now that dezincification in sintering has been overcome. Dezincification has been stopped largely through the use of

Copper-base powders have earned much respect in bearing and like applications and now new alloys make such powders usable for other machine parts.



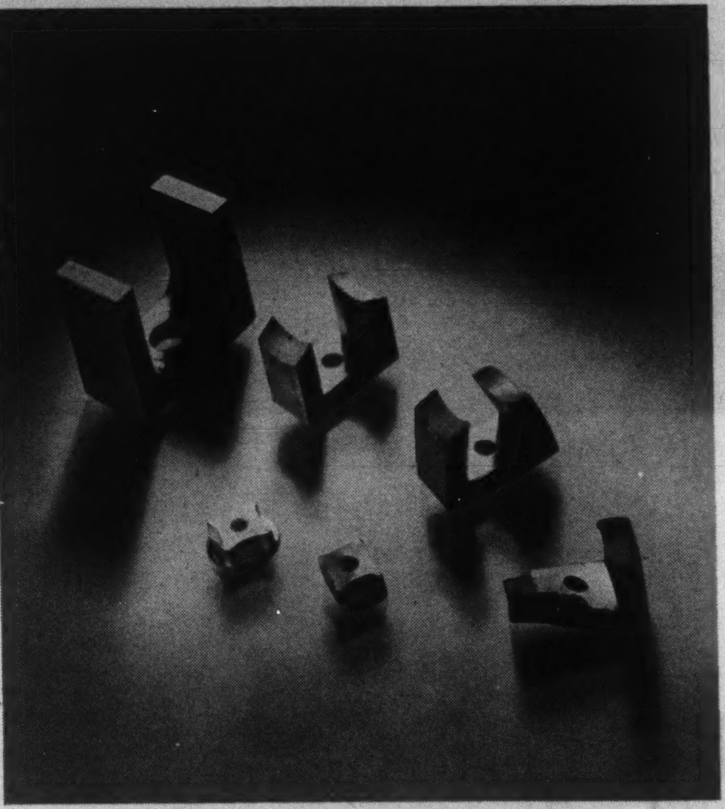
At 100 X magnification, 70-30 brass is shown to have particles that are irregular in shape. Particles of this type interlock under compression to form strong green compacts.

moisture-free controlled atmospheres during sintering.

Conclusive tests on brass powder metal parts produced under laboratory conditions by the New Jersey Zinc Co. show such parts to have interesting properties. The results of such tests are shown in Table I. It will be noted that phosphorus has been added to some brasses. Phosphorus increases ductility without significant change in other physicals. More important, phosphorus reduces the optimum sintering temperature range in a 70-30 brass from 1650 to 1560 F and broadens the sintering range from 70 to 100 F.

Tensile strength is not greatly affected by changes in copper content of the powders, but high copper increases the sintering range, whereas, unless phosphorus is present, the sintering range is so narrow, when copper is less than 70%, that it is seldom possible to attain maximum tensile properties commercially. When close control of weight and dimensions is important, advantages are gained from a high copper content. Alpha brasses (70% or higher copper) have greater green strength than the beta brasses (65% or less copper).

Parts of pure copper and those containing 70% copper and 30% nickel are among those being produced as sintered compacts, but the common physical properties of these parts are not so significant as are purity, electrical and electronic characteristics, resistance to corrosion, malleability or some other properties, or producibility in shapes hard to make otherwise, at least at equal cost. This becomes clear when specific parts subsequently described are studied.



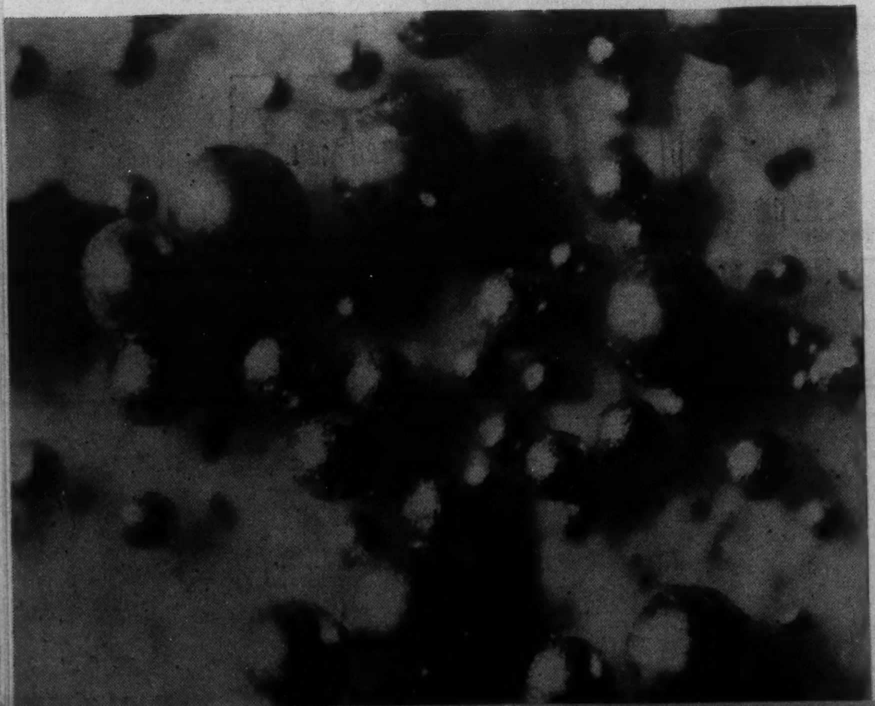
Some of these brass powder parts have been distorted to demonstrate how much abuse such parts withstand. Note the sharp knife-like edges on some. (Courtesy: Merrimam Bros.)

Types of Parts Produced

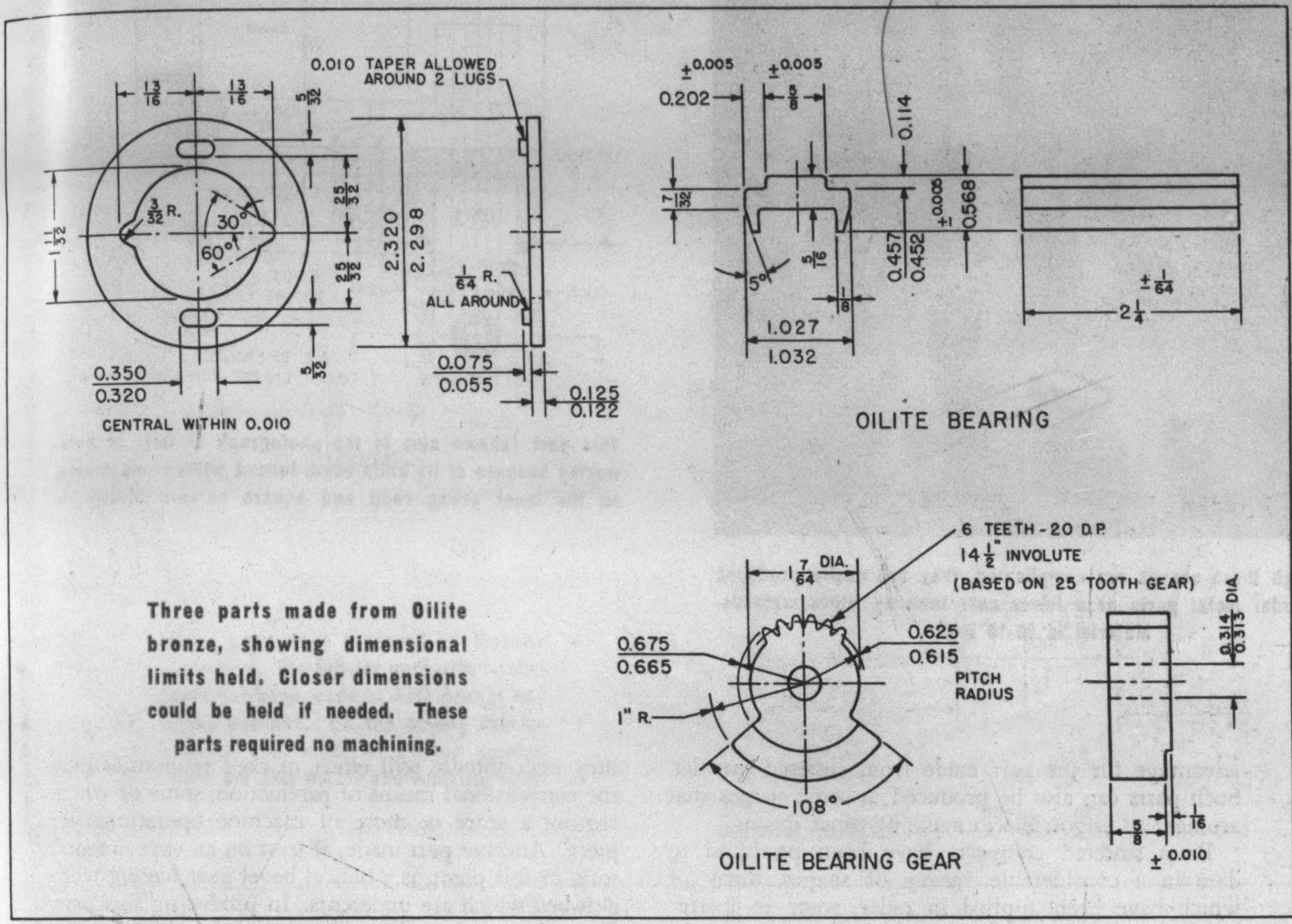
Most of the products made in the form of sintered copper-base compacts fall into one of the following classifications:

1. Mechanical parts
2. Bearings
3. Filters, flame arresters or diffusers
4. Electrical or electronic products

In the first classification (mechanical parts) most work appears to have been done with bronzes, partly because they are easily sintered and are made most extensively by companies that manufacture porous bronze bearings as major products. Mechanical parts of sintered bronze powder have suitable properties for many purposes in which cast bronze might be used but have the important advantage of being pro-



Spherical 70-30 brass powder particles shown at 100 X magnification. Such particles are rather weak in the green state, but are excellent as strong porous filters after sintering.


0.010 TAPER ALLOWED AROUND 2 LUGS
13/16
13/16
5/32
3/32 R.
30°
60°
1 11/32
25/32
25/32
2.320
2.298
1/64 R. ALL AROUND
5/32
0.350
0.320
0.075
0.055
0.125
0.122
CENTRAL WITHIN 0.010
±0.005
0.202
±0.005
5/8
0.114
7/32
5°
5/16
1/8
1.027
1.032
0.457
0.452
±0.005
0.568
±1/64
2 1/4
OILITE BEARING
6 TEETH-20 D.P.
14 1/2" INVOLUTE
(BASED ON 25 TOOTH GEAR)
1 7/64 DIA.
0.675
0.665
0.625
0.615
PITCH RADIUS
1" R.
108°
0.314 DIA.
0.313
5/8
1/16
± 0.010
OILITE BEARING GEAR

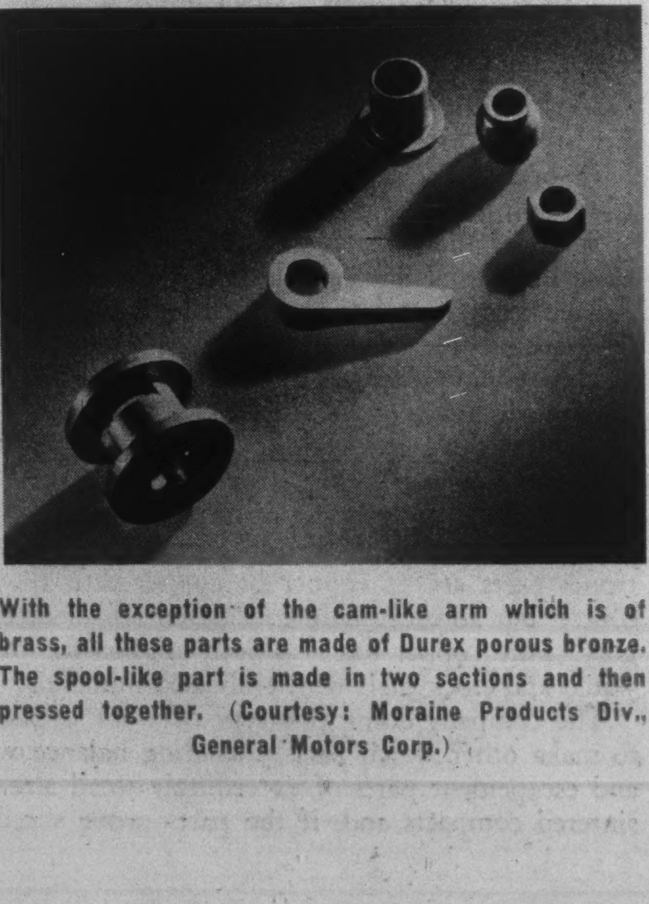
Three parts made from Oilite bronze, showing dimensional limits held. Closer dimensions could be held if needed. These parts required no machining.

duced, as sintered, within quite close dimensional limits and, as coined, within still closer limits. In general, little or no machining is required and surfaces are far smoother than on sand cast parts, being equal to those on most wrought metal parts. Moreover, if the part is one that requires lubrication, the pores can be filled with oil to provide the lubrication and thereafter require a minimum of attention on that score.

Illustrated parts of sintered bronze powder and captions indicate how useful such parts are. It is clear that equivalent parts made by other means (except, perhaps, by die casting) would cost much more largely because of the extensive machine work needed. It is, in fact, chiefly because sintered compacts can be made in somewhat intricate shapes that otherwise would be expensive to machine that this method of production is chosen.

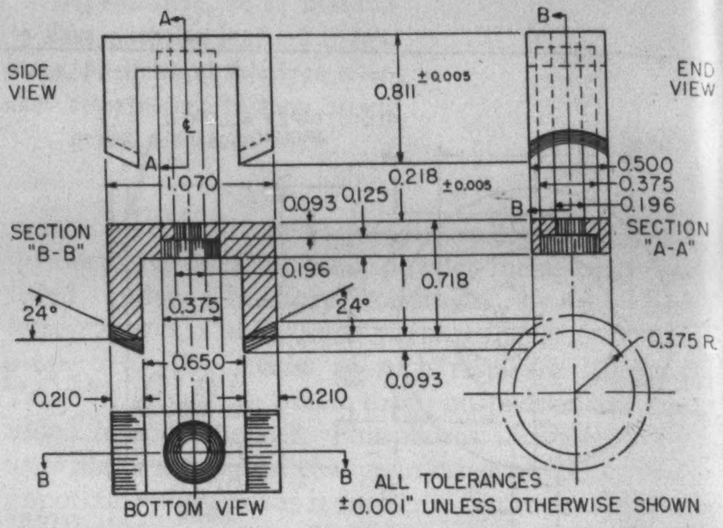
In other words, the saving in machine work allows a margin of profit that, in general, gives the sintered compact its market as a mechanical part. Powders cost considerably more *per pound* than most equivalent cast and wrought metals, but this is offset in the sintered compact by savings in machining, rapid production and (usually) by little or no loss in chips or scrap.

Where a porous metal is wanted, for convenience in lubrication or for some other reason, there is an added



With the exception of the cam-like arm which is of brass, all these parts are made of Durex porous bronze. The spool-like part is made in two sections and then pressed together. (Courtesy: Moraine Products Div., General Motors Corp.)

Although these shapes are complicated, they are easily produced as powder metal parts at a lower cost than by other methods. Material is 90-10 brass.



This part (shown also in the photograph at left) is noteworthy because of its knife edge, formed without machining, on the inner prong radii and square corners elsewhere.

advantage for the part made from sintered powder. Such parts can also be produced in some shapes that are next to impossible to make by other means.

Brass sintered compacts have been produced to date in a considerable variety of shapes, many of which have been applied in radar, some in instruments and others for diversified mechanical uses the nature of which even the makers do not always know. Dimensions often are held within ±0.001 in. and sometimes ±0.0005 or closer, usually excepting height (parallel to motion of compressing punches) on which ±0.005 in. is generally required, much as for other powder parts. These dimensions are held, as a rule, on the coined part rather than on the sintered compact.

This is little or nothing to choose in respect to finish between brass and bronze parts. Some brass parts have been made with exceedingly sharp edges, not commonly recommended in powder metal products.

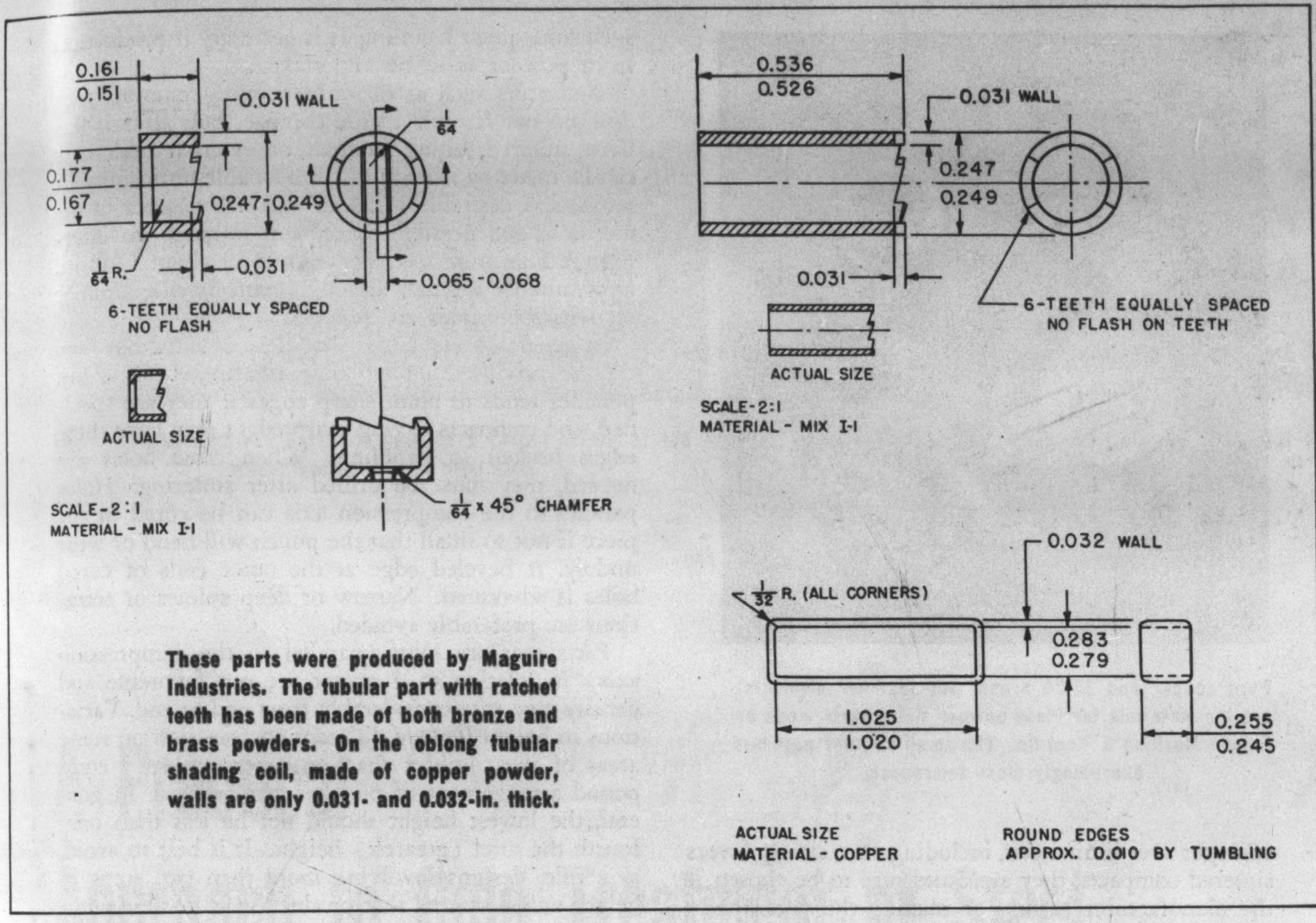
Some of the most remarkable parts in respect to close limits and intricate design have been produced for electronic applications from pure copper. Many of these are for electronic tubes in which pure and gas-free components are a prime essential and exceedingly close limits on certain critical dimensions must be held without machining. Tooling of the highest precision is required but is warranted by the results secured, especially as some of these are practically impossible of attainment by other means. Not all electronic parts are of copper or copper-base alloys, of course, but all those here considered are in that category. Pure copper has also been applied for making watch and clock dials with embossed numerals.

The company doing this type of work is planning to make other watch parts, including balance wheels and escapement parts of exceedingly small size from sintered compacts and, if the parts prove successful, they undoubtedly will effect marked economies over the conventional means of production, some of which require a score or more of machine operations per piece. Another part made, at least on an experimental scale in this plant, is a helical bevel gear having teeth between which are undercuts. In producing this part, either the punch or the compact must be given a slight angular motion about the compression axis to clear the compact, but this appears to be practical.

To date, as far as the author is aware, all filters, flame arresters and similar products having controlled porosity, produced on a commercial scale, have been made either from bronze by companies whose primary business is porous bronze or porous iron bearings, or from copper. Both make good filters that are readily sintered and are high in corrosion resistance, but the same can be said also of brass. Since brass powders suitable for making filters are now available at a price below that for bronze powders, there is reason to anticipate that brass powders may soon find utility in the filter field.

Except for sintered copper-base compacts in which porosity serves a useful purpose and for those on which no applied finish is needed, the question of plating often arises. Plated finishes are feasible, at least on products of high density, but the appearance and serviceability of the plate depends (much as with other types of plated parts) upon adapting the plating process to the product.

Pores in any plated product may not be bridged by the plate, which is also porous and, if plating solutions remain in the pores, they are likely to work out and cause noticeable defects in the plated surface subsequently. This suggests extreme care in rinsing and drying. It also suggests careful tests, under service conditions, if possible, to make sure that plating will stand up as desired.


0.161
0.151
0.031 WALL
1/64
0.177
0.167
0.247-0.249
1/64 R.
0.031
0.065-0.068
6-TEETH EQUALLY SPACED
NO FLASH
ACTUAL SIZE
1/64 x 45° CHAMFER
SCALE-2:1
MATERIAL - MIX I-1
0.536
0.526
0.031 WALL
0.247
0.249
0.031
6-TEETH EQUALLY SPACED
NO FLASH ON TEETH
ACTUAL SIZE
SCALE-2:1
MATERIAL - MIX I-1
0.032 WALL
1/32 R. (ALL CORNERS)
0.283
0.279
1.025
1.020
0.255
0.245
ACTUAL SIZE
MATERIAL - COPPER
ROUND EDGES
APPROX. 0.010 BY TUMBLING

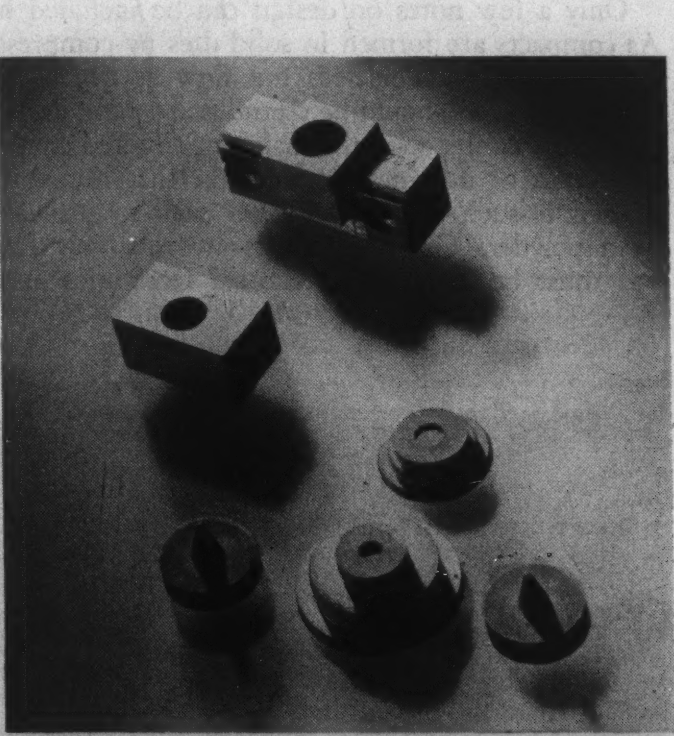
These parts were produced by Maguire Industries. The tubular part with ratchet teeth has been made of both bronze and brass powders. On the oblong tubular shading coil, made of copper powder, walls are only 0.031- and 0.032-in. thick.

Applications here cited afford a clear indication that sintered copper-base compacts have made a deserved place for themselves in the metalworking field. They can do certain jobs better or more economically or both than they can be done by other means. Where and as long as this holds true, the sintered compact will continue in demand. It will also be applied, of course, where its porosity (and consequent ability to absorb lubricant and feed it as needed) is desired and where other unique properties are essentials.

Competitive Considerations

The best opportunities for meeting such competition as powder metal parts encounter appear to be in those applications where a considerable amount of machine work is saved. The more numerous and time consuming these operations, the better is the opportunity for the sintered powder product. This presupposes, of course, that the product will meet service requirements, as it clearly can do in an increasing variety of applications.

Where a substantially equivalent part can be produced on the screw machine, stamping press, forging press, extrusion press or by die casting or some other casting process, some degree of competition must be anticipated. Each of these processes has its own advantages and limitations, just as that involved in making sintered compacts does. Where the balance of ad-



The three small electronic parts are of copper and the other parts of 70% copper and 30% nickel powders. (Courtesy: Merriam Bros.)

Pure copper and 80-20 brass (for fastener elements) are the materials for these powder metal parts made by Falcon Machine & Tool Co. The small circular part has exceedingly close tolerances.

vantages over limitations, including cost, clearly favors sintered compacts, they are quite sure to be chosen if the manufacturer buying or making the part knows and takes advantage of the facts.

Notes on Design

Only a few notes on design can be included here. As compacts are formed in solid dies by compressing punches and powder does not flow as liquid metal does, these facts should be considered by the designer. He should confer with the maker of sintered compacts on details of design unless certain that the product desired is such as to lend itself well to production from powder. Green compacts are relatively fragile and must be capable of removal from dies and of such subsequent handling as is necessary if production from powder is to be undertaken.

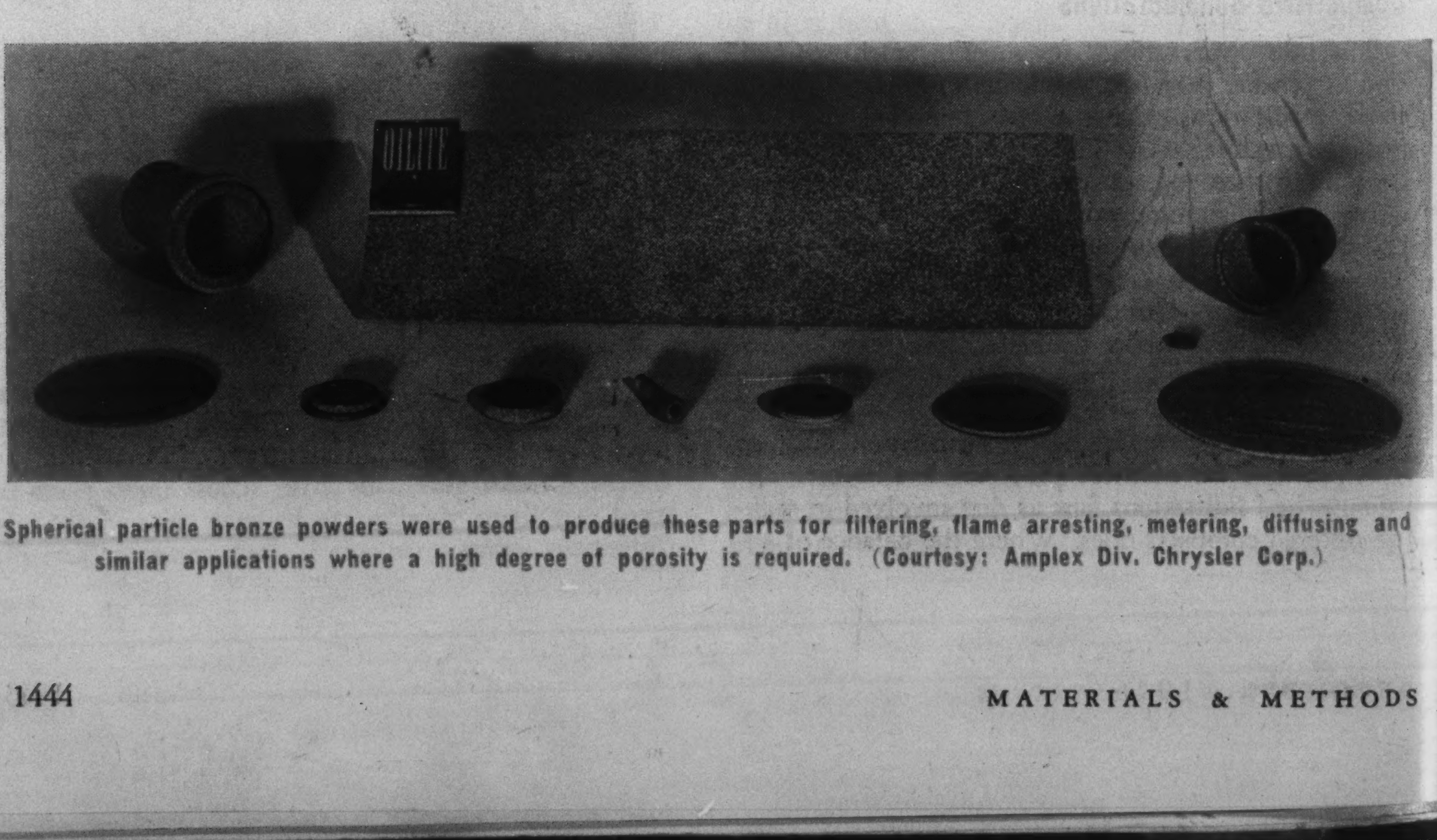
Undercuts such as to interfere with removal from dies are not feasible in the compact but, after it has been sintered, either internal or external undercuts can be made by machining. Reasonable uniformity in sections is desirable to avoid unequal changes in dimensions and possible consequent warpage in sintering. A minimum section thickness of about 1/16-in. is commonly desired, although parts having thinner sections sometimes are feasible.

In general, sharp edges should be avoided but they can be produced under some conditions. Wear on punches tends to blunt sharp edges if they are specified, and compacts having sharp edges may have these edges broken in handling. When cross holes are needed, they must be drilled after sintering. Holes parallel to the compression axis can be cored in the piece if not so small that the punch will bend or wear unduly. A beveled edge at the outer ends of cored holes is advocated. Narrow or deep splines or serrations are preferably avoided.

Parts that are long (parallel to the compression axis) in relation to diameter are not favorable and density may vary considerably from end to end. Variations in height involve different compression on some areas of the compact than on others unless a compound arrangement of punches can be used. In general, the lowest height should not be less than one-fourth the total (greatest) height. It is best to avoid, as a rule, designs involving more than two steps in height unless assured that production is feasible without undue tooling costs.

Tapers usually require a land or cylindrical surface at the end. Any construction that necessitates a sharp edge at the end of a punch should be avoided as this edge will not remain sharp long in contact with an abrasive powder.

There are exceptions to nearly all rules or recommendations for the design of any type of part, including those relating to sintered compacts. When such rules or recommendations can be followed without sacrificing essential requirements, however, costs are likely to be lowered or a better product or both commonly result.



Spherical particle bronze powders were used to produce these parts for filtering, flame arresting, metering, diffusing and similar applications where a high degree of porosity is required. (Courtesy: Amplex Div. Chrysler Corp.)

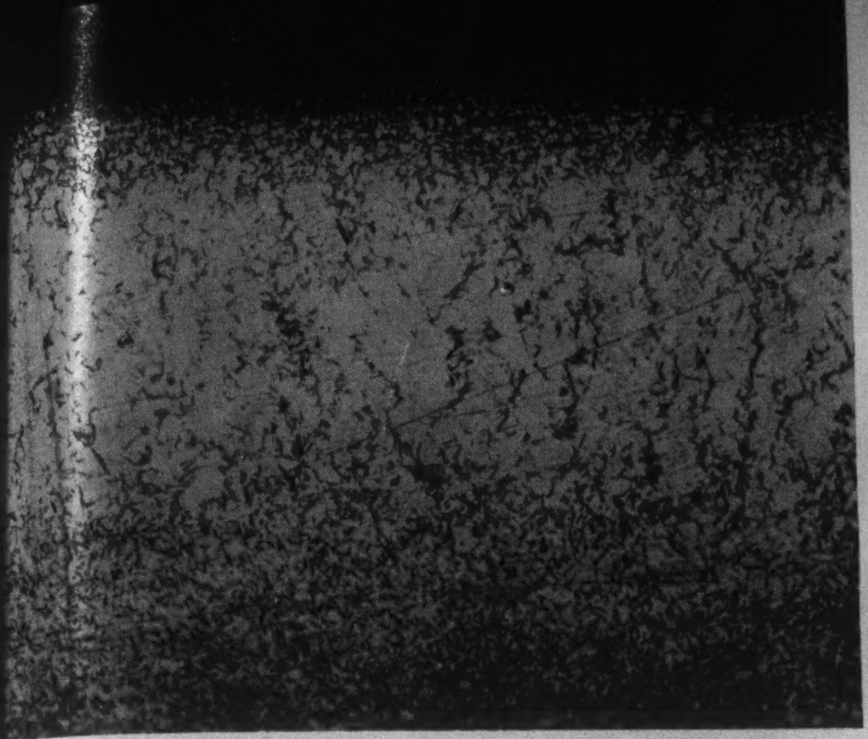


Fig. 1—Carburized and hardened case of a pinion shown at 100 X magnification after a Nital etch.

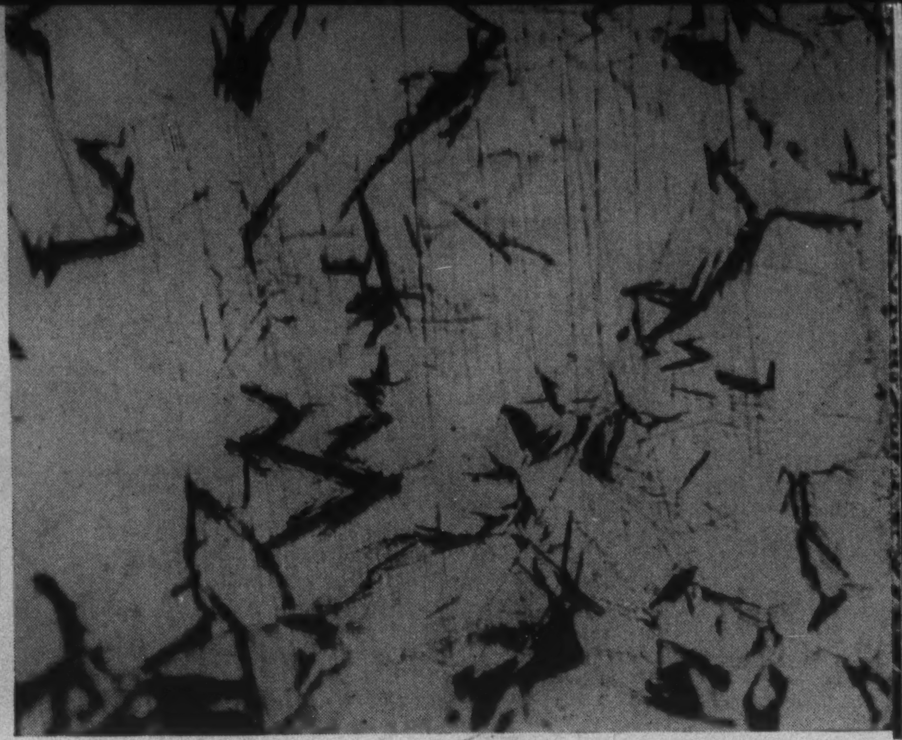


Fig. 2—This is the same zone as shown in Fig. 1 except that magnification is now 1000 X.

A Practical Approach to Cold Treatment of Steel

by **ORLO E. BROWN,** *Chief Metallurgist, Western Gear Works*

> Like any other process, cold treatment must be applied intelligently, so here the author tells where and why low temperatures are likely to be helpful.

EVEN BEFORE SECURITY CONSIDERATIONS were relaxed, a great deal of information had been published on the subzero treatment of steel. While much has been added to our general knowledge, it must be admitted that the very number of articles has tended to confuse many steel processors. They find themselves aware of the possible benefits of cold treatment, but unable to answer for themselves such questions as the following:

Will cold treatment help their product?

How does one tell, without extensive tests and micro-examinations (which they may not be equipped to conduct) just when to use cold treatment?

How much benefit can be expected?

Only as heat treaters and shop foremen, as well as engineers, become familiar with cold treatment can it bring full benefits to industry. Its use must be understood so that not only theoretical considerations, but shop tests as well can determine when it should be used.

Generally speaking, it is the purpose of cold treatment of steel to increase hardness and to produce a more uniform and stable metal. Unfortunately, it is not possible to increase the hardness of steel or improve uniformity whenever and wherever needed merely by use of refrigeration. Only when the steel is in one of two conditions can cold treatment be effective. These are:

A. When the metal is a supersaturated solid solution. Room temperature iron (ferrite) has a solution

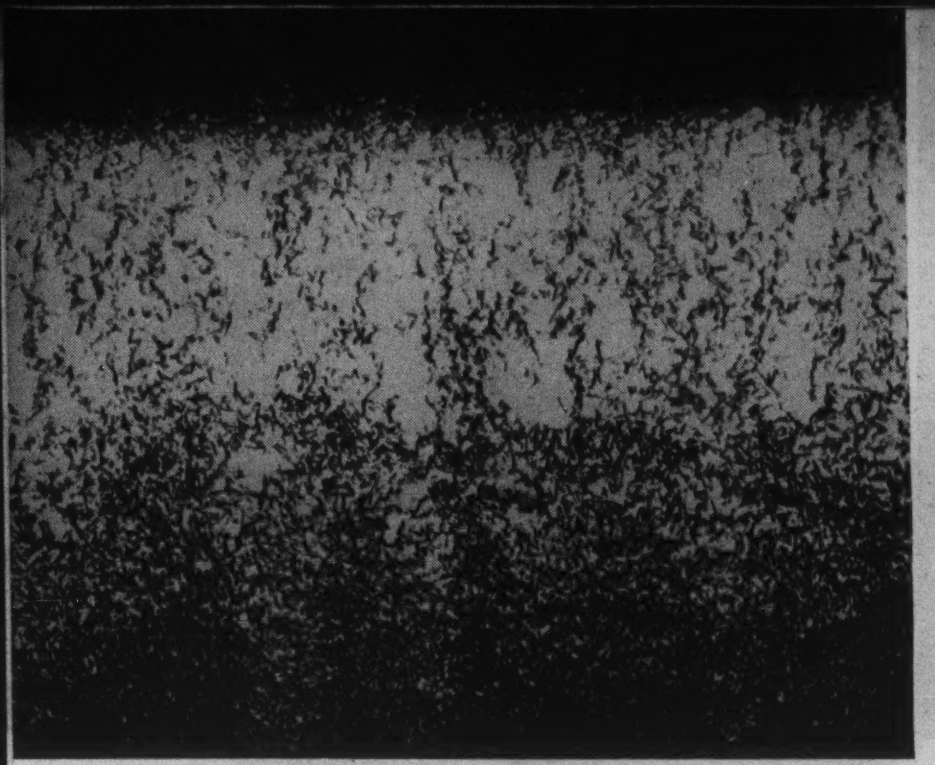


Fig. 3—Carburized and hardened case after 425 F draw magnified 100 X.

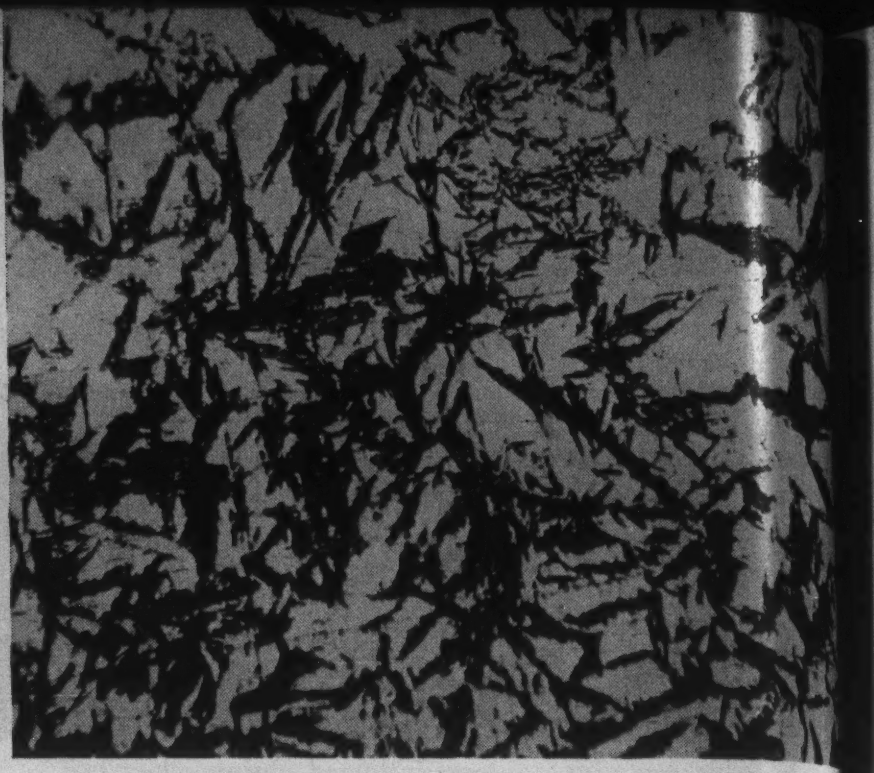


Fig. 4—The area shown in Fig. 3 is here shown at 1000 X.

ability for carbon far below that of iron at elevated temperatures (austenite). Hence, the metal may have dissolved in it at 1500 F much more carbon than it can dissolve when cold. A sudden quench may prevent the separation of the carbon "excess" and result in a metal which at room temperatures is in a supersaturated condition.

B. When the steel is supercooled.
If the steel is quenched from a temperature at which it is austenite, presence of considerable dissolved carbon or alloying elements, or both, may so interfere with the change from austenite to ferrite plus pearlite during the cooling that the austenite structure may be retained at room temperature. This constitutes a supercooled condition.

While the surest way of determining if a certain metal meets either of these conditions is usually examination under the microscope, it is often possible to get this information by a very simple procedure. Nothing more complicated is needed than a Rockwell hardness tester and a file. First, the analysis and heat treatment of the metal should be checked. Benefits from cold treatment are practically a certainty when the character of the steel is as follows:

1. Medium to high carbon or alloy steel, or with both medium to high carbon and alloy content.
2. In the "as quenched" or quenched with low temperature draw condition.
3. "File hard" or nearly so, yet with a Rockwell C hardness under 55.

The expression "file hard" is used somewhat loosely to indicate a hardness which feels slick to a file, that is, the file does not get a "bite" of the metal. It should be noted that even a low carbon steel which has been carburized can have all three of these characteristics in the case. An explanation of some practical examples will serve to illustrate both how it was determined that cold treatment should be used, and also what improvements were realized from the treatment.

Typical Uses

SAE 3312 steel has been widely used for heavy duty parts which are to be carburized and hardened. Its analysis (see Table I) gives a tough core and excellent hardenability. Ordinarily this steel can be carburized by any of the usual methods, quenched, and tempered to produce a case of 61 Rockwell C or better, and a core of 33 to 44 Rockwell C. However, when the amount of carbon in the skin goes over a certain percent (usually about 0.98%) or the rate of quenching is excessive, an entirely different result will be obtained. Both the case and the core will have hardnesses of 30 to 40 Rockwell C. The characteristics outlined in (1) and (2) of the preceding paragraph have been obtained with the results given under (3). A pictorial description of the appearance and correction of this failure of the case to respond to quenching is given in the first six photomicrographs. They were taken of a pinion which had been made of SAE 3312 bar stock. Its treatment had been:

Gas carburized 7 hr. at 1700 F.
Diffused 6 hr. in neutral atmosphere at 1700 F.
Rapidly cooled in neutral atmosphere to 1550 F.
Oil quenched in a quenching fixture.
Tempered in salt bath at 300 F.

Fig. 1 was taken of the case at 100 diameters. There is a very shallow zone of martensite along the surface which probably came from getting a partial air quench in going from the furnace to the quenching fixture. It is too thin to support the diamond for even a satisfactory Rockwell A hardness reading. Below that is a deep layer of austenite with a few zig-zags of a black decomposition product of austenite. There is also some barely discernible martensite through it. The matrix is austenite, however, and the characteristics of the case are those of high carbon austenite. Below and toward the interior of the pinion there is martensite, first the inside fringe of the case, then the core martensite. Fig. 2 is the same as Fig. 1 taken just below the skin martensite at 1000 diameters. This

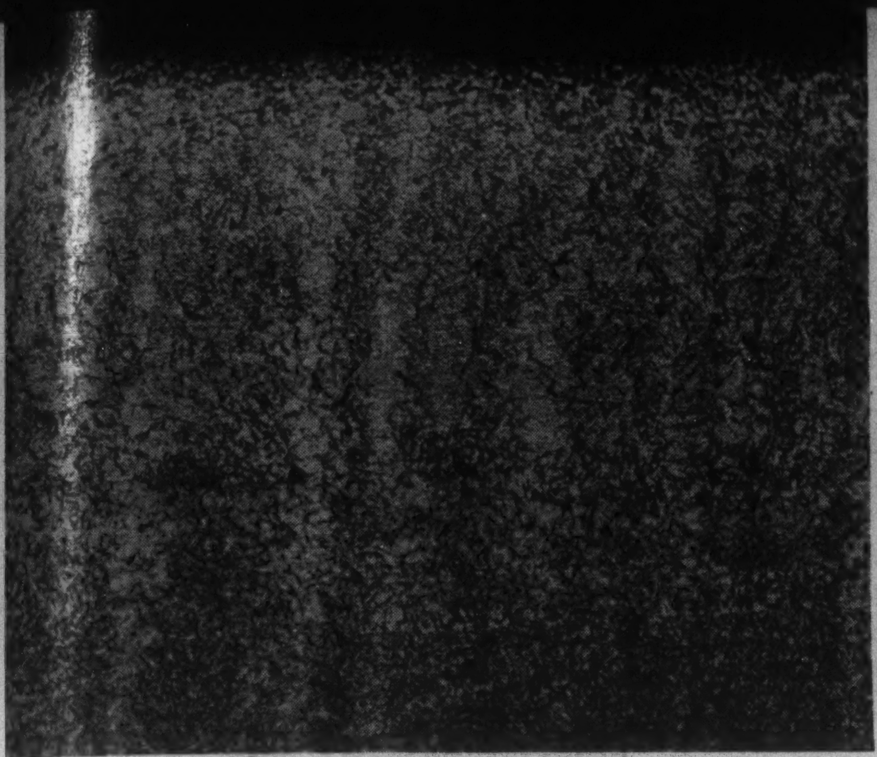


Fig. 5—Carburized and hardened case after cold treatment at −115 F for 6 hr. Magnification 100 X.

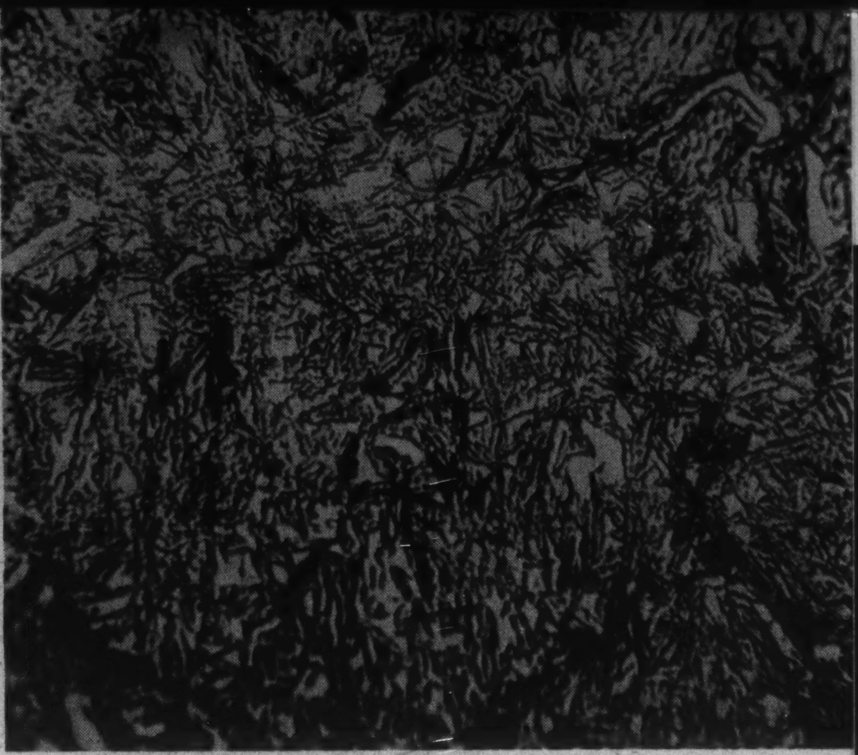


Fig. 6—Further details of the area shown in Fig. 5 are revealed when 1000 X magnification is used.

shows more clearly the predominant austenite and the dark needles. Hardness of the case in this condition was 38 Rockwell C.

When it was found that austenite had been retained (condition B), a tempering treatment of 425 F was used. It was thought that a higher temperature than the 300 F already used on this part would stimulate the decomposition of the austenite. Although the Martensite Point of this steel is about 820 F, that high a temperature could not have been used because it would have tempered the core softer than was permissible, irrespective of its effect on the case. The basis for this tempering is the fact that martensite, although harder than austenite, is one step below austenite when it comes to rapidity of quench for its development, consequently can be obtained by the decomposition of austenite under proper conditions.

In Figs. 3 and 4 are shown the effect of the 425 F heating. Comparing Fig. 3 with Fig. 1, it can be seen that the austenite zone is slightly narrower after the higher tempering treatment. Fig. 4 shows considerable austenite decomposition, but to the undesirable black needle-like structure rather than to martensite. It is undesirable because its hardness is inferior to that of martensite. There is one patch of martensite (upper center of picture), but the matrix is still austenite. This structure represents an unstable steel, although the hardness had actually increased from that of the as quenched condition. Following tempering at 425 F the hardness was 42 to 43 Rockwell C.

After the second tempering failed to produce satisfactory hardening, the pinion was given the cold treatment. It has 6 hr. at −115 F followed by a 300 F draw. The results are shown in Figs. 5 and 6. Fig. 5 shows nearly uniform martensite from surface to core. The banded structure is characteristic of bar stock. While a few traces of austenite remained (see Fig. 6), it is evident that a very hard and uniform case had been obtained. Actual check of the case gave 63 to 64 Rockwell C. It should be stated that normal use of cold treatment does not need to be preceded by a 425 F draw, although a 300 F draw afterward is recommended. To summarize the results of cold treatment of this pinion:

Hardness in Rockwell C

	Case	Core
As quenched (300 F draw)	38	33
After 425 F draw	42 to 43	35
After cold treatment (−115 F)	64	35
After final 300 F draw	63 to 64	35

A second example of improving the case of a carburized gear is shown in Fig. 7. This helical gear was machined from SAE 4620 steel. After being gas carburized at 1700 F to give a case 0.040- to 0.050-in. deep, it was direct quenched in oil from 1700 F. While it was "file hard," the Rockwell C readings were low enough to cause rejection of the gear. This posed a problem for the Inspection De-

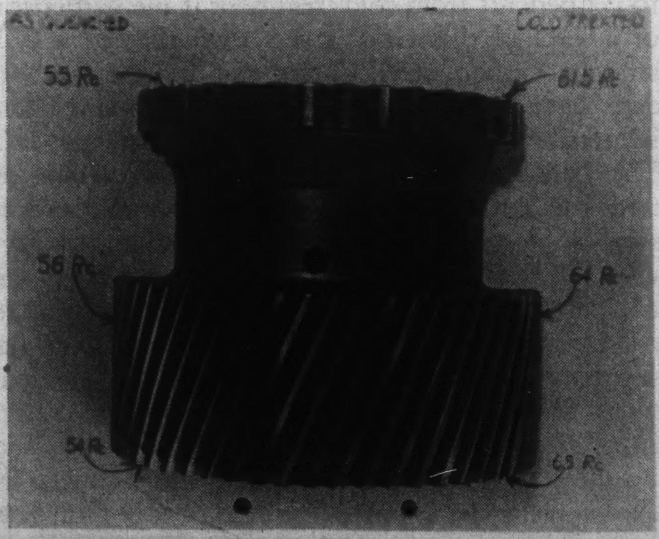


Fig. 7—On this helical gear of SAE 4130 steel proper hardness was attained through cold treatment after it became apparent that considerable austenite was retained after quenching.

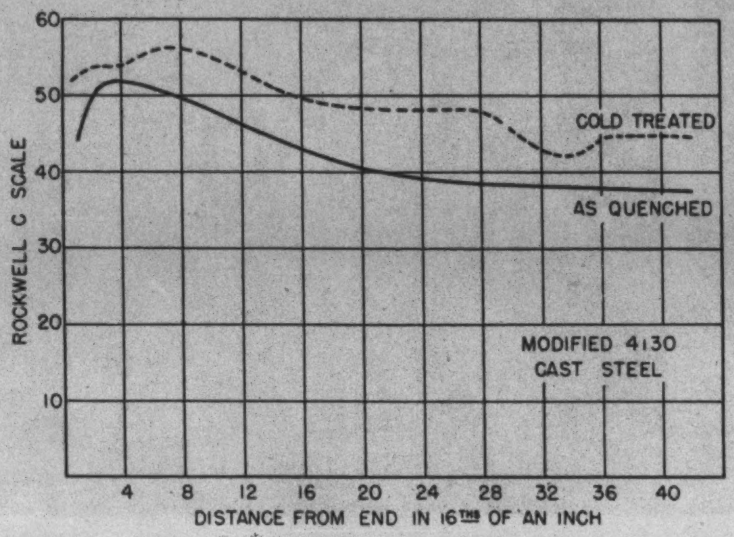


Fig. 8—In this test, cold treatment increased hardness at all distances from the quenched end.

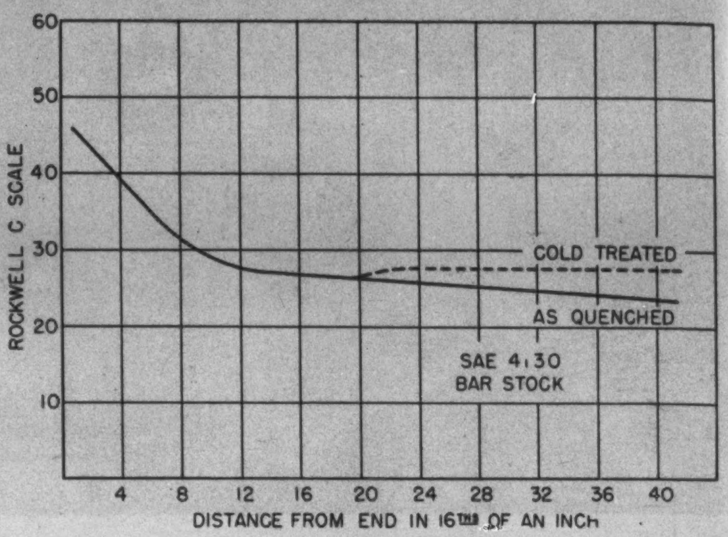


Fig. 9—Further tests are being conducted to see whether the apparent difference in hardness is an experimental variation or actual hardening.

partment, since no modern plant wants to rely on a "file test" in preference to an impartial testing machine for determining hardness. Since test pieces accompanying the gear during carburizing proved that a deep enough case had been obtained, it seemed evident that the quench hardness was poor due to retained austenite (condition B). The gear was cold treated, and this conclusion was borne out by the increased hardness as shown in Fig. 7. In this example the decision to cold treat was based entirely upon comparison of Rockwell C readings and apparent "file hardness." No samples were run except the low carbon rod used to check case depth during carburizing. No microscopic examination was made.

Test Data on Various Steels

When it comes to using cold treatment in the processing of medium-carbon medium-alloys steels, general rules cannot be given. One should not expect to get benefits from cold treatment if the hardenability of a steel of this class is less than that of a 0.50% straight carbon steel. Tests run by the author to date have consisted of subjecting standard Jominy hardenability test bars to cold treatment at −120 F. The bars had been checked in the usual way and, after the hardenability curves had been obtained, they were cold treated. Some representative results are given in Figs. 8 to 11, inclusive. Fig. 8 is for a cast steel of modified 4130 composition. From the analysis given in Table I it can be seen that this steel had a slightly higher manganese, silicon and molybdenum content than SAE 4130. It also had a somewhat larger grain size. It is evident that cold treatment had a beneficial effect on the hardness at all distances from the quenched end. No such result was obtained with SAE 4130 (Fig. 9). The small difference in the right hand portion of the curve after cold treatment is being further investigated to determine if it is experimental variation or an actual hardening. SAE 4130 had a clue in its as quenched Jominy hardenability curve to what might be expected from cold treatment. Absence of a drop in hardness at the surface or even a flat in the curve at a 38 Rockwell C level (hardness of austenite of this carbon content) indicated absence of retained austenite. As a result, no significant response to cold treatment was expected.

SAE 4140 had a flat in the as quenched curve at the level of martensite hardness. Effect of sub-zero temperatures on one test bar is shown in Fig. 10. With NE 9920 there was practically no effect. It can be stated that the slight variation shown in the curve represents experimental differences in a small number of specimens rather than any significant change in hardness.

Although the advantages of cold treatment on tool steels have been demonstrated many times, it might be of interest to show one example of supersaturation (Condition A) in which the effects on the microstructure was photographed. This test employed twist drills made of high-speed steel. As they were received from the manufacturer, the metal had a microstructure at 1500 diameters, as shown in Fig. 12. The matrix is austenite grains with a moderate number of carbide particles scattered throughout, particularly along grain boundaries. After cold treatment, the number of carbide particles had more than doubled. The low temperature had stimulated the precipitation of carbon previously held by the austenite. While a change in hardness alone means little in a drill already over 62 Rockwell C, it is evident that the presence of twice as many abrasive particles throughout the drill will appreciably improve its cutting ability.

In this test half of the drills in one box averaged 27 holes each on a certain job before sharpening became necessary. The other half of the same box was cold treated and averaged 63 holes each under the same working conditions. These drills were used on a production line during normal operations. Even greater improvement was indicated when the consistency of the drills was compared. Some untreated drills made as few as 11 holes before needing sharp-

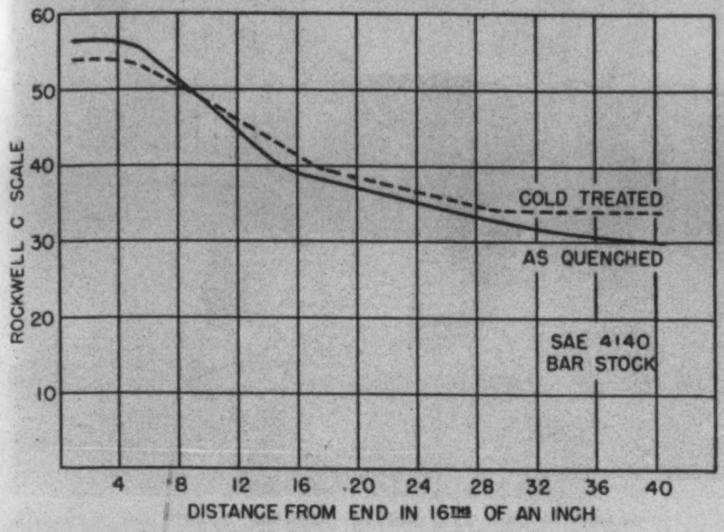


Fig. 10—On SAE 4140 bar stock little effect resulted from cold treatment. The slight variation shown is considered to be experimental differences in a small number of specimens.

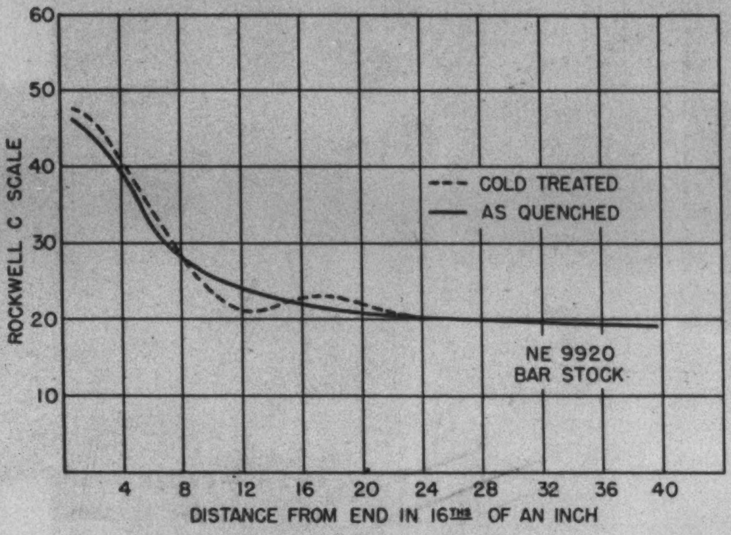


Fig. 11—Cold treatment, tests show, has little if any real effect upon NE 9920 bar stock.

ening, while all treated ones cut at least 50 holes. The difficulty in the use of cold treatment on tools is knowing when the proper conditions exist in the metal to allow improvement. Unfortunately, this class of steel does not lend itself readily to rule-of-thumb determination of its condition, as do the steels of the previous examples. Usually microscopic examination at high power is the only way that the character of the structure can be determined. Of three types of small tools tested at the time that the above data was obtained, two showed no appreciable change as a result of cold treatment, and only the drills improved.

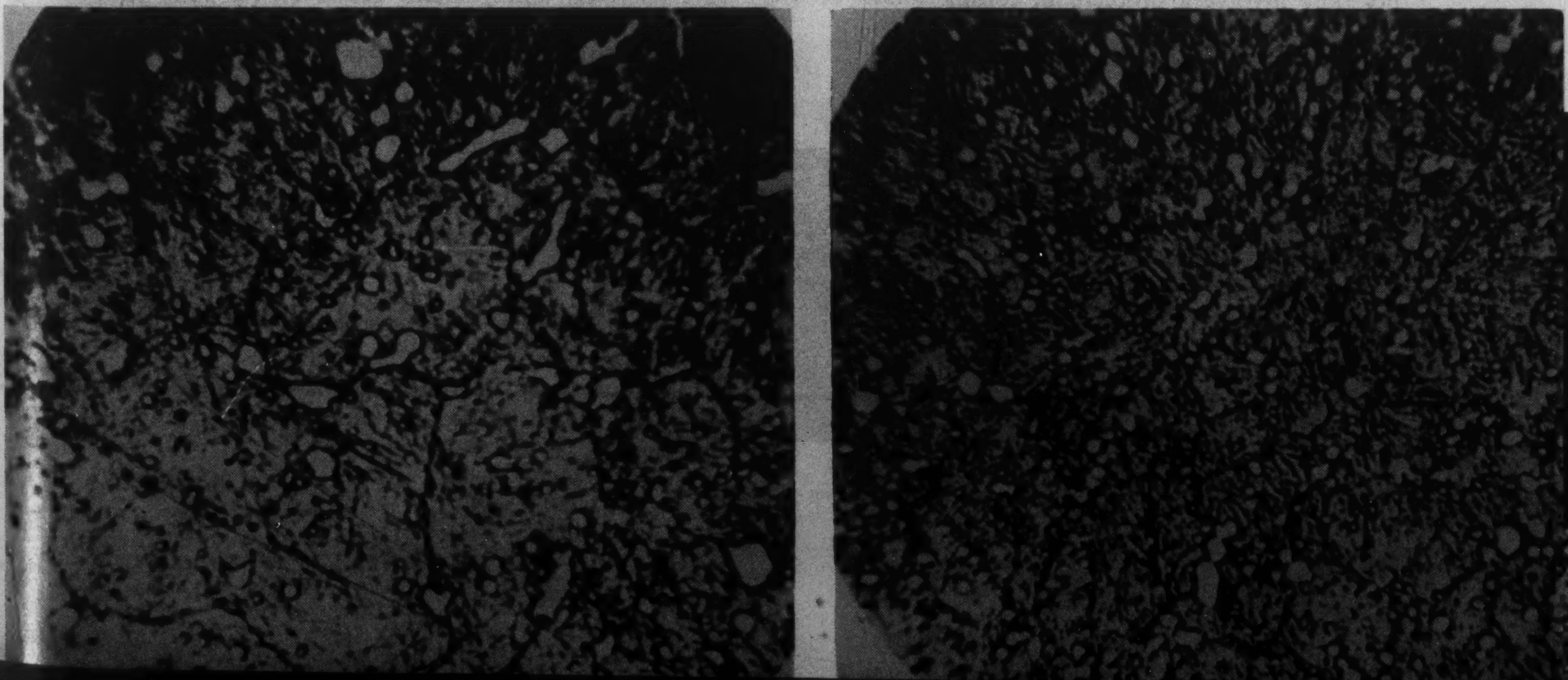
Conclusion

Methods have been suggested by which manufacturers of hardened steel parts can determine for themselves whether or not cold treatment will improve their product. With SAE and similar steel, the checking is accomplished by simple shop tests. If the type of metal is such as to be susceptible to super-cooling or supersaturation, then the hardness is checked. When the apparent hardness and Rockwell C hardness do not agree, the probability is that cold treatment will be beneficial. Actual trial will tell if the improvement obtained offsets the cost of treatment.

Table I—Analysis of Steels Used

	SAE 3312	SAE 4620	MOD. 4130	SAE 4130	SAE 4140	NE 9920
Carbon	0.11	0.19	0.32	0.33	0.42	0.21
Manganese	0.48	0.59	0.95	0.46	0.54	0.54
Phosphorus	0.025	0.035	0.030	0.030	0.027	0.007
Sulfur	0.015	0.021	0.035	0.021	0.022	0.018
Silicon	0.25	0.28	0.50	0.29	0.26	0.28
Nickel	3.61	1.88	—	—	—	1.17
Chromium	1.45	—	0.90	0.99	0.99	0.49
Molybdenum	—	0.22	0.30	0.21	0.19	0.25

Figs. 12 and 13—Cold treatment of a high speed steel drill as received from the manufacturer resulted in an interesting change in microstructure. Shown (left) is the microstructure as received while the same drill (right) after a 4 hr. cold treatment shows twice as many carbide particles. The result is better cutting ability. (Magnification 1500 X.)



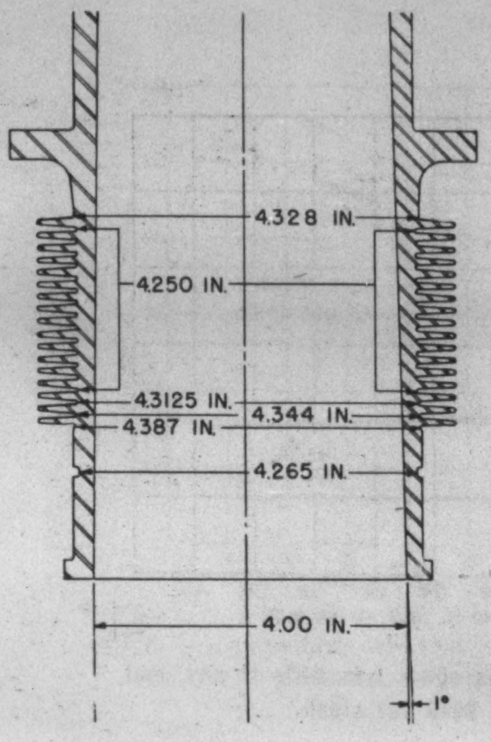


Fig. 1 — Design details of a cylinder produced by the casting method using refractory molds.

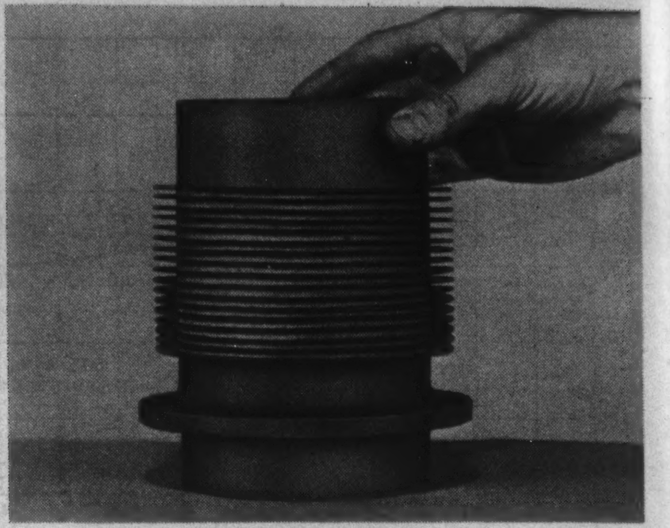


Fig. 2—A finished casting of the type shown in the drawing presented in Fig. 1.

Precision Cast Finned Cylinders

by E. I. VALYI, *A. R. D. Corp.*

[illegible] functional features of various
[illegible] casting methods is used to produce
cylinders which require thin layers of
metal and heavy sections side by side

FINNED HOLLOW CYLINDERS for aircraft engines are usually manufactured from cast or forged blanks. The fins, the mounting flange, etc., are developed by machining, such as turning or milling. The limitations of machining economy prevent consideration of many cooling fin shapes, spacings and sizes which otherwise might offer interesting design possibilities.

The A. R. D. Corp. has been occupied for a considerable length of time with the problem of how to produce exceedingly thin layers of cast metal in juxtaposition to heavy sections. As is well known in foundry practice, such sudden changes in crosssection not only involve a problem in complete flow of hot metal through thin sections, but the question also arises as to the amount of residual stress remaining at the junction of the heavy section and the thin section due to the difference in the rate of cooling of the metal in these two areas.

By means of refractory mold casting, the A. R. D. Corp. has produced first in its laboratory, then, commercially, at the plant of its licensee, the Midwest Foundry Co., Coldwater, Mich., a finned hollow cylinder (Fig. 1) with fins 0.030-in. thick projecting from a cylinder wall which is itself 0.15-in. thick. Since in this application the fins act only as a means for rapid heat transfer, the tolerances on such a casting are relatively unimportant. However, for other structures involving problems of precision, it is well to point out that tolerances of 0.002-in. per in. are commercially feasible.

The steps taken to produce this finned cylinder required a pattern made of a special plastic of such composition that low temperature and low pressure injection molding could be employed. Almost complete absence of residual stresses in the plastic pattern gives a minimum of distortion and close control of dimensions. The low cost of this pattern material contributes greatly to the economic feasibility of the process.

The next stage in the process is the molding of a low cost refractory around the plastic pattern; the

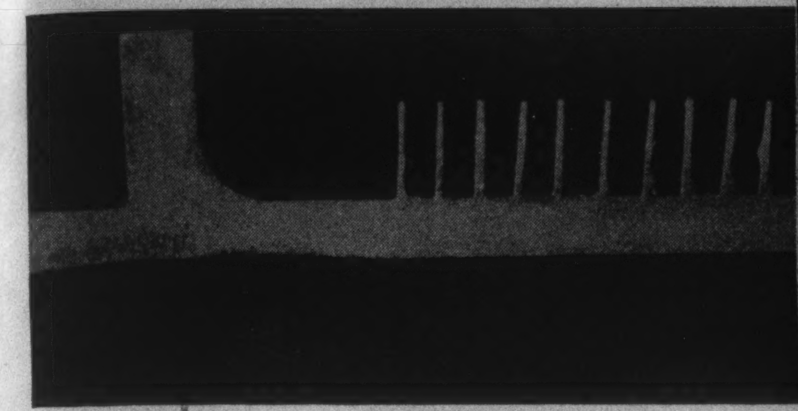


Fig. 3—This finned section—actual size was etched in 50% hydrochloric acid to show the absence of porosity.

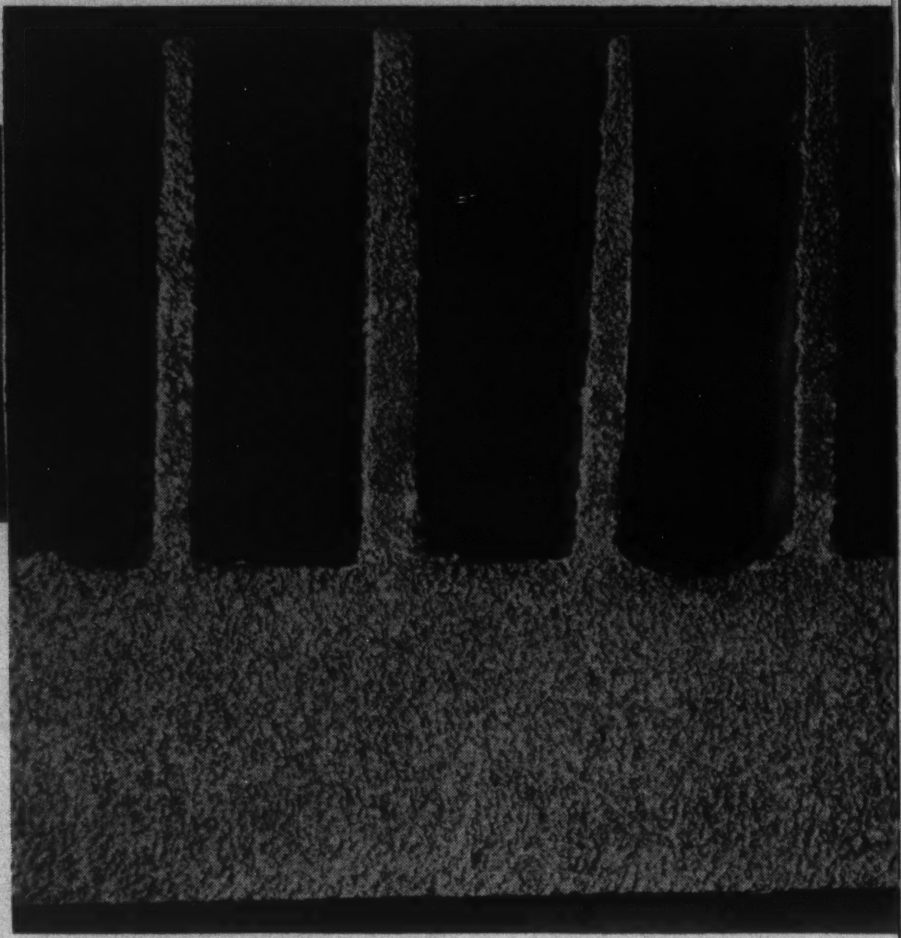


Fig. 4—A section of the finned area enlarged six times shows uniformity of steel structure.

mold is subsequently fired and the cylinder is cast centrifugally, spun on its own axis with an acceleration of approximately 110 G.

The finished cylinder (Fig. 2) illustrates the possibilities now open to the designer of aircraft engines. The fins are clean and smooth and the structure solid throughout. A section cut longitudinally through the cylinder wall (Fig. 3) has been etched in 50% hydrochloric acid to show the absence of porosity. A smaller area of the same section (Fig. 4) has been enlarged to illustrate uniformity in the steel structure.

The photomicrograph (Fig. 5) at 80X etched in nital shows a section through a fin. An area at the base of one of the fins is shown in (Fig. 6). The steel is a plain carbon steel of medium carbon content. No heat treatment for refining the grain has been given the cylinder, and the photomicrographs represent the structure as cast.

Refractory mold casting of thin fins on heavy sectioned castings can be produced most economically and this procedure offers large production rates at low cost. Advantage will no doubt be taken of the fact that the shape of the fin is no longer limited by the requirements of machine shop practice, but that both size and shape could be designed for the maximum of both aerodynamic and thermodynamic efficiency.

Patents are pending on this newly developed process.

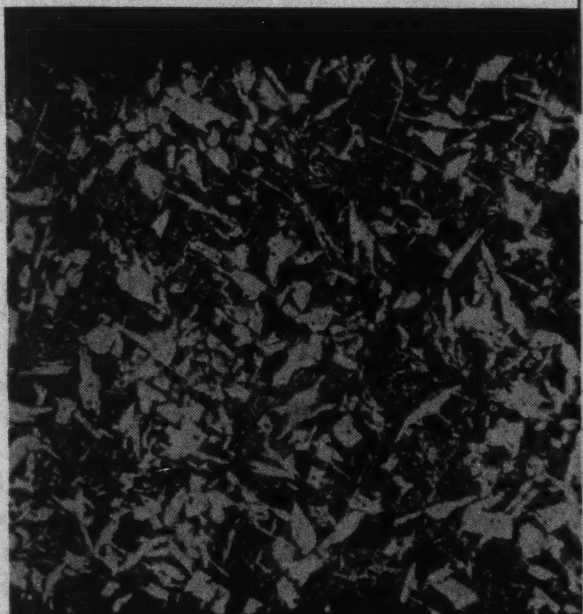


Fig. 5—At 80 X magnification a section through a fin appears this way.

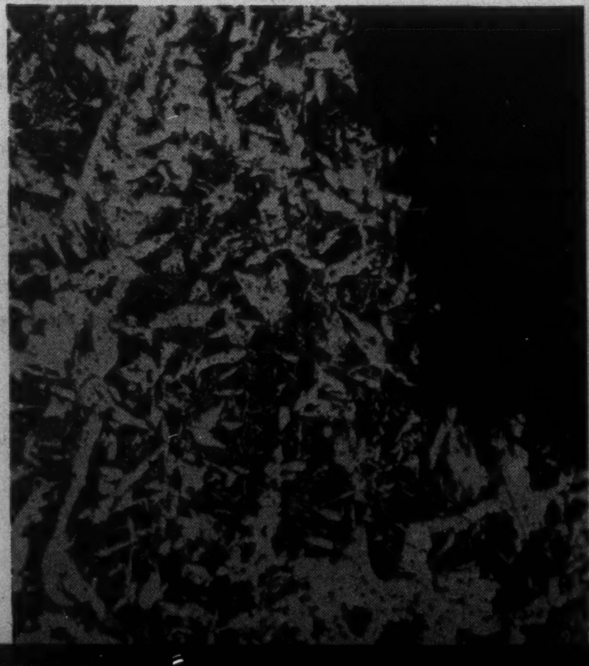


Fig. 6—The area at a fin base (80 X) shows almost identical structure with that of the fin.

To complete this two-part series on methods of drying industrial finishes, we now cover the capabilities, limitations and uses of convection heating.

Drying Industrial Finishes on Metals

The Convection Heating Method

by **H. R. CLAUSER,** *Associate Editor,* MATERIALS & METHODS

IN AN EARLIER INSTALLMENT (MATERIALS & METHODS, October, p. 910), the infra-red radiant heating method of drying industrial finishes was discussed. To complete the picture we now discuss the convection heating method, its characteristics, capabilities and limitations.

Heating by convection is simply a matter of heat transfer from a heat carrying medium—usually air—to a cooler body. So, to dry, cure, or bake finishes by convection, heated air is circulated against the painted parts; the parts and the finish are thus raised to the proper processing temperature.

Air may move naturally through the oven or it can be forced. In natural convection heating, the circulation of air in the oven is due to temperature difference. Since the rate of circulation is low and not dependable, natural convection is seldom used for drying industrial finishes. Forced convection—the mechanical circulation of heated air—gives a more uniform oven temperature and a higher rate of heat transfer; it is therefore used in almost all convection oven designs.

The amount of heat actually transferred by convection depends upon the difference in temperature between the hot air and the receiving surface and upon the rate (weight per unit of time) at which the hot air passes over the receiving surface. So, the greater the difference in temperature between the heated air and the work, the faster will be the rate of heating. Likewise, the greater the weight of heated air circulated per unit of time, the faster will be the rate of heating.

Types of Convection Ovens

Sources of heat for convection systems include fuel fired air heaters, steam, and electricity. Fuel fired air heaters, using either gas or oil, are most commonly used. The limiting factor of electricity is its cost. A recently developed source of heat has been high pressure hot water which can be used in the temperature range attainable with steam (up to about 300 F).

The air in convection ovens can be heated by such sources of heat either of two ways, indirect or direct heating.

In the indirect heating method, no products of combustion enter the oven. Air passes through or over a heat exchanger, is heated, and in turn heats the oven. The heat exchanger is essentially a series of tubes which are heated by products of combustion from a combustion chamber. Steam or hot water can also be used to heat the tubes. Indirect air heating units are mounted either directly in the oven or separate from the oven. Internally mounted systems can employ electric side-wall heaters, fire tubes or steam pipes; they are usually low-cost installations and are not as satisfactory as the externally mounted designs.

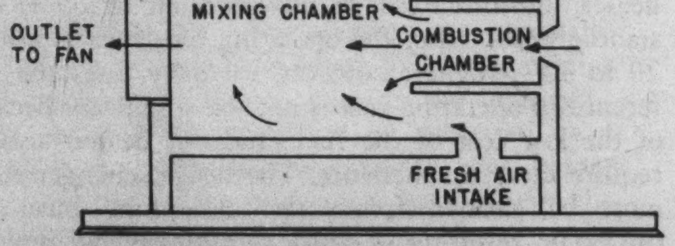
In the direct heating method, the products of combustion resulting from the burned fuel are mixed with a predetermined quantity of air and this hot mixture heats the oven. As in an indirect heating system, the direct air heaters can be mounted either in the oven itself or as separate units externally. In internally mounted types, burners are placed along the bottom

Some convection ovens are huge, as is this four-pass oven used for drying finishes on automobile bodies. (Courtesy: J. O. Ross Engineering Corp.)

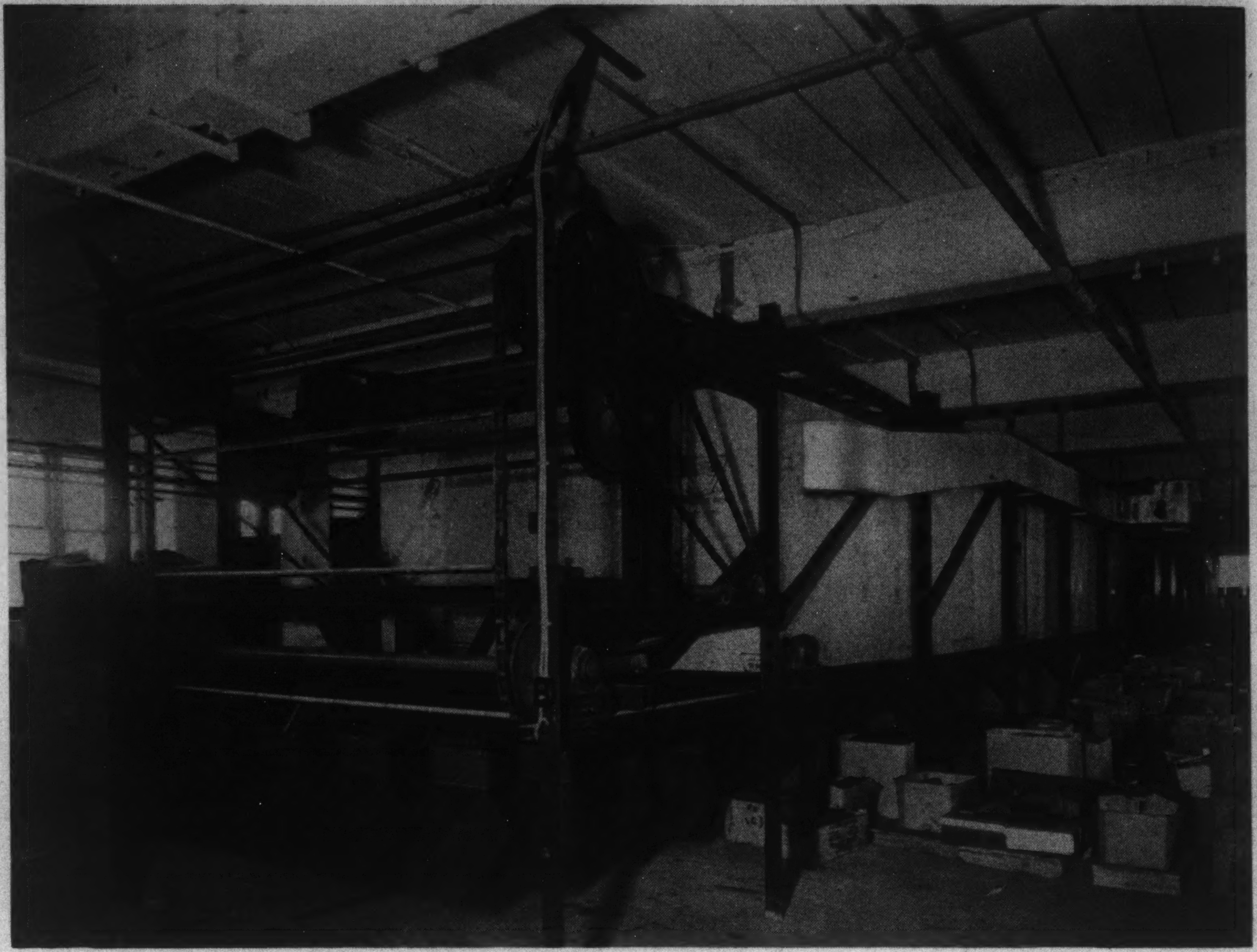
or sides of the oven, but are separated from the processing area by a partition. Air is drawn by fans through the combustion compartment and into the oven through suitable duct work. At one time the burners were placed directly in the processing compartment, but that design is now obsolete.

Externally mounted direct air heaters have a combustion chamber and a mixing chamber. The gas or oil burners in the combustion chamber give off hot products of combustion which enter the mixing chamber. Here they mix with fresh air and recirculated air from the oven. This mixture at the desired temperature is forced through ducts and into the oven by air circulating fans.

Until recent years indirect heating was used almost exclusively for drying finishes, because it furnishes clean air uncontaminated by combustion gases. Direct air heating was formerly avoided because the products of combustion tended to discolor finishes and give them a dull, gloss-less finish (called frosting). But improved design of direct air heaters has eliminated this one big disadvantage. In the most recent designs,



This cross-sectional view shows the essential elements of a typical external direct air heater as used in the drying by convection of industrial finishes.



This conveyor convection oven is used for baking synthetic enamels and wrinkle finishes on filing cabinets. (Courtesy: Gehnrich & Gehnrich)

the products of combustion are diluted with large quantities of fresh air to prevent harmful effects to the finish. Too, paint manufacturers have learned how to formulate their paints to counteract the frosting action of the combustion gases.

The direct heating method, with the air heater mounted externally, has a number of characteristics which favor it over the indirect heating method. In comparison with the externally mounted indirect heater, the initial cost of the direct air heater is substantially less. Also, the operating efficiency is usually 20 to 30% higher; however, in many cases the difference in operating cost is not too significant because of the low cost of the fuel. Indirect heaters usually require more maintenance. The heat exchanger tubes must be cleaned frequently; also, tube burn-outs can occur, resulting in costly shut-downs and replacements. Where weight is a critical factor, direct heaters have an advantage. Indirect air heaters (externally mounted) are as much as eight times heavier than direct air heaters.

Perhaps the most important advantage of externally mounted direct air heaters is their ability to provide a high rate of air delivery and high oven temperatures. Indirect heating systems are capable of oven temperatures up to around 550 F, while direct air heaters can give temperatures up to as high as 1200 F. This means that with direct air heaters the drying or baking temperature of a given finish can be reached more rapidly.

However, successful use of direct air heating for drying industrial finishes requires careful design and control, and for this reason cannot be considered to be as "fool-proof" as an indirect heating system. Careful regulation of the fresh air input and the recirculated air is necessary. In drying finishes where vapors can burn to form acidic end products (*i.e.,* with chlorinated solvents) none of the oven atmosphere can be recirculated.

All in all, it is evident that the trend in modern convection drying is toward the adoption of the externally mounted direct heating system wherever applicable to provide high oven temperatures and large air delivery rates.

Process Design Considerations

For any given finish there is a proper baking cycle; that is, the finish must bake a specified time at a definite temperature. Because of this, speed of the

DESPATCH OVEN CO.

Finishes on metal containers are dried in this convection oven which has an externally mounted direct fired air heater. (Courtesy: Despatch Oven Co.)

drying cycle, itself, cannot be increased. However, the total time required to process a finish through the oven can be reduced by bringing the work up to baking temperature more rapidly. In convection heating, the speed of heat transfer to a painted object—therefore, the rate of temperature rise—can be hastened by increasing the temperature difference between the oven hot air and the object's surface, as well as by stepping-up the delivery rate of the hot air. Until recently the temperature difference in convection ovens was limited to about 100 F to insure uniformity and to eliminate all possibility of over heating. Also, hot air delivery rates were not at the maximum. Now, convection oven designs call for increased air volumes and temperature differentials so that higher heating speeds can be obtained wherever desirable.

When drying finishes that can withstand the sudden application of high temperature, the "surge" principle can be used. The system is so designed that the oven temperature for the first part of the cycle is several hundred degrees above the optimum baking temperature in order to heat the part rapidly. As the part reaches baking temperature, the oven temperature is lowered to meet it. This method is easily applied to batch ovens. A controller, activated by either the oven or inlet air temperature, can maintain a high temperature until the work approaches the optimum curing temperature; then it can cut back the temperature of the oven so that the increasing metal temperature of the part does not exceed the curing temperature.

In conveyorized systems, oven zoning offers good possibilities for fuel economy and for greater speeds in bringing the work to the baking temperature. Such arrangements permit the work, as it leaves the oven, to preheat air for the oven; or parts can enter the oven through a preheat zone where low boiling point solvents are removed before entering the high temperature zone; or the parts can be subjected to a very high temperature in the entrance zone before moving into the major processing zone where the baking temperature is maintained.

For good quality and uniform finishes the oven design must provide close control of the work temperature and time. In modern convection ovens, control of the baking cycle is achieved by regulating the air inlet temperature, the rate of air delivery, and the conveyor speed. In some cases where heating speeds are very high, it has been found that oven temperature regulation cannot be relied upon, but that the time in the oven becomes the governing factor.

In convection heating the shape of the part does not, in general, appreciably effect the curing cycle. However, good oven design requires that the oven atmosphere be properly circulated. Consideration must be given to the correct application and direction of air flow, depending upon such factors as the size and shape of the parts which might be processed and the method of loading. Closely related to proper air circulation is the removal of vapors given off during the drying process. Since many solvent vapors are explosive and undesirable from the standpoint of good working conditions, means of exhausting them quickly and efficiently from the oven must be provided. Rapid vapor removal is usually accomplished by using high rates of air delivery and using fans to exhaust the vapor-contaminated air. In continuous oven installations, air curtains can be used at the ends of the oven to keep the vapors from the surrounding areas.

A factor in convection heating not often considered is the heat transferred to the oven by radiation from the oven walls. If the oven walls are well insulated, their temperature will closely approach that of the inlet air. With the higher air-inlet temperatures now being used, the radiant heat transfer from the walls is becoming a significant factor. It has been reported in some cases, even under moderately forced convection, that approximately 50% of the heat reaches the work by low temperature radiation.

Capabilities and Limitations

One of the most important advantages of the convection heating method is the uniform heating medium it provides. Convection heating is inherently uniform. This fact, plus the close control that can be achieved by regulating the heated air temperature and air delivery rate, assures uniformity. In properly designed convection installations, all factors such as heat deliveries, volumes and velocities are calculated so that slight variations in temperature can be controlled. Thus, an even temperature throughout the oven can be maintained and no part of the pieces being processed can attain a temperature higher than the oven atmosphere. Also, since the heated air flows over and around the work surfaces, regardless of their location or their position in the oven, fairly dense loadings are possible. The only requirement to be met is that the loading must be such that the heated air can contact the surfaces of the work.

Another advantage of convection heating is its flexibility. Flexibility is made possible largely by close control of the time and temperature factors. The requirements of any baking cycle can be met by adjusting: (1) the air inlet temperature, (2) the rate of air delivery, (3) the conveyor speed, and (4) any combination of these factors. Thus, a variety of finish drying jobs can be handled by the same installation. Different parts varying in size, shape, thickness, color or type of finish can be handled by adjusting any of the factors listed.

Convection drying is suitable for all conventional metal finishes whether they cure by evaporation, polymerization or oxidation. However, where direct fired ovens are used, care must be taken to use paints which are so formulated as to avoid the possible unfavorable effect of combustion products. When curing by convection, rate of temperature rise in the part is not influenced by the color of the finish. All other conditions being the same, a black and a white finish would both have the same curing cycle in a convection oven. This makes possible the satisfactory baking of multi-colored finishes on the same part.

The speed of convection drying as compared to other methods, such as infra-red radiant heating, is highly controversial; it is difficult to discuss conclusively because of the many variables and considerations involved. It is true, however, that recent developments in convection heating, chiefly the successful adoption of direct fired ovens with higher temperature differentials, have made possible processing speeds closely approaching those attained by infra-red methods. In many applications there is no appreciable difference in the time required to process finishes by the two methods.

To give some idea of the drying speeds possible with convection ovens (externally mounted, direct air heater type), here are two typical cases:

Lamp bases with synthetic finishes ranging from white to dark brown; baking temperature, 350 F; time, 4 to 5 min.

Fuel pumps with synthetic, polymerizing finish; baking temperature, 325 F; time, 8 min.

Another factor which must sometimes be considered is the time required to bring the oven up to the working temperature. With radiant heating, this heating-up period is not required (except in ovens where both convection and radiant heating are used). In convection heating, the oven atmosphere must be heated to the desired temperature before the processing can begin. This time lapse may or may not be significant, depending on the particular circumstances in each case.

Conclusion

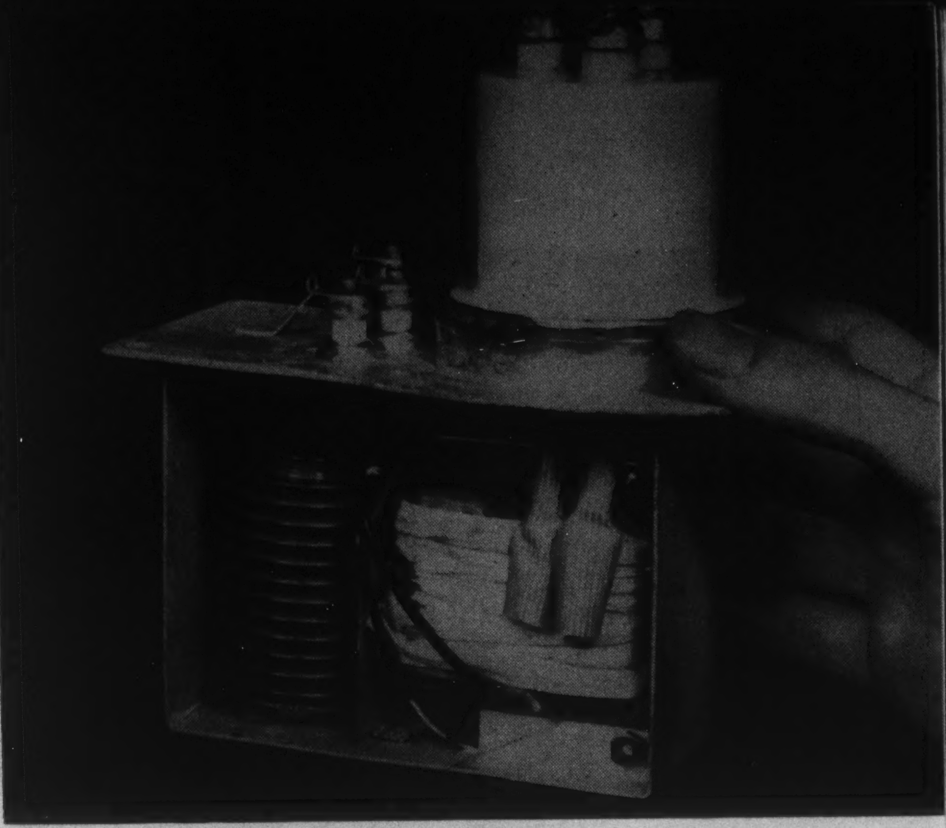
Both convection heating and infra-red radiant heating methods have been described in this two-part article. The essential features of the two heating processes and of the equipment and operation have been outlined. Also, the capabilities and limitations of each have been broadly covered. From the discussion it is evident that both heating methods have a definite place in the drying of industrial finishes on metals. Choosing applications to which each is best suited is a matter that must be decided on the basis of the conditions and requirements in each individual case.

Acknowledgment

We wish to thank the following organizations for providing much of the material contained in this article:

Despatch Oven Co.
Gehnrich & Gehnrich
J. O. Ross Engineering Corp.

It is in this type pulse transformer that the new core steels found wide application.



A New Radar Transformer Steel

by G. H. COLE and R. S. BURNS, *Associate Directors of Research, The American Rolling Mill Co.*

MANY PEACETIME APPLICATIONS are predicted for a new magnetic alloy developed during the war specifically to increase the effectiveness of radar pulse transformers. Many of the characteristics of this electrical steel were proscribed through cooperative research under the leadership of the Massachusetts Institute of Technology Radiation Laboratory.

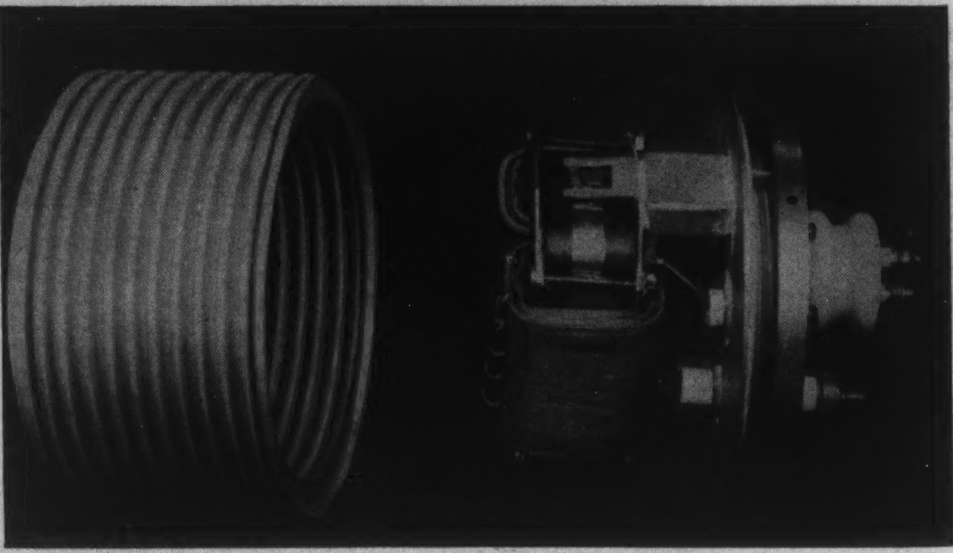
The new alloy, which has a carbon content of less than 0.01% carbon, made possible the development and manufacture of the lightweight sensitive radar equipment which did so much to make our bombing raids over Europe and Japan as devastating as they were.

With only the magnetic core material available at the beginning of the war, radar could not have accomplished what it did in the latter part of the war.

This low carbon, high silicon steel made possible the compactness and high efficiency of American military radar and radio transformer equipment.

As the war progressed, the various stages in the development of radar required thinner steel for the transformer cores as well as improved magnetic quality. A large tonnage of coils of electrical steel containing 3 to 3.5% silicon was rolled by one manufacturer to 0.003 in.—the thickness of a sheet of paper. Many thousands of pulse transformers for use by our Armed Forces were made from this material. Then new requirements necessitated the reduction of the strip thickness to 0.002 in. so as to decrease the energy consumed in the magnetic core of the pulse transformer. This energy, called core loss, caused overheating of the electrical equipment. An even more important effect of excessive core loss was reduction of the effective range of radar and of the sharpness of radar images on the oscilloscope—the device for receiving the reflections of the electrical waves when the radar beam intercepted an enemy plane or ship.

Eddy-current loss, which is one of the components of this energy loss, was known to decrease rapidly with a decrease in the thickness of the laminations in the transformer core used in the radar circuits. An increase in the silicon content of core material was also known to be helpful in reducing eddy current loss, but the silicon content could not be increased much beyond 3% without interfering to a prohibitive degree with the rolling of the steel to very thin gages. Alloys of too high silicon content had the ad-



Here with the removal of the bellows case can be seen the transformer core of this recently developed steel.

ditional disadvantage of poorer permeability at very high magnetizing forces. The successful commercial production of very thin steel in large quantities made possible the reduction of eddy current losses, with only 3% silicon-iron alloy, to such a degree that these losses were no longer the limiting feature in the design of the new magnetic core material and the devices in which it was used..

Furthermore, it was noted by research workers studying the manufacture of radar steel that reductions in the eddy current component of core loss were accompanied by an increase in the remaining portion of the core loss. However, it was observed that this increase could be prevented in certain light gages of electrical steel by a new method of processing involving combinations of favorable chemical analysis, the proper amounts of cold reduction, and suitable heat treatments.

The New Alloy

The alloy used was one containing 3% silicon with the remainder almost pure iron. For example, carbon content was kept below 0.01%. By this combination of analysis with suitable cold reduction and heat treatment, the hysteresis component of core loss was kept low even for steel only 1 or 2 mils thick. Without this combination of treatments the hysteresis loss in very thin steel would increase as the thickness of the core material was reduced until the advantage in the reduction of the eddy current component was offset.

This improved processing resulted in a strip having the best combination of properties for the types of microwave radar equipment that were under development near the end of the war. For this type of service the best combination of properties that seemed attainable in such extremely thin steel was:

(a) Thickness—1 to 2 mils.
(b) Electrical resistivity of at least 45 microhm-cm. to help insure low eddy current loss.
(c) Low hysteresis considering gage and tendency for the hysteresis loss per unit weight to be high in very thin strip.
(d) High lamination factor; that is, a minimum of volume occupied by a given weight of thin steel when formed into a transformer core.
(e) The strip must be well insulated without a substantial reduction of the lamination factor.
(f) High effective permeability. The conditions of the pulse transformer application required (1) a high permeability parallel to the direction in which the steel was rolled for high magnetizing forces, (2) high saturation induction, and (3) hysteresis of the material so low that the magnetic flux would drop to a low value in the presence of a very small air gap after each pulse without the complications involved in artificially reducing this magnetic remanence.

The high lamination factor was attained by large amounts of cold reduction under such conditions that the strip was free from excessive buckles or waves. The strip was given a final annealing treatment under uniform temperature conditions, so that the flatness of the strip was improved and the minimum hysteresis loss produced.

Insulation on the strip was produced by a method which involved a chemical treatment of both sides of the strip, followed by treatment at a high temperature to insure permanence of characteristics. Thickness of the insulative layer, judging by micrographs, was only a few hundred-thousandths of an in. The high insulation resistance was attained by the completeness of the coverage of each microscopic area. Coverage by other than chemical methods, such as by repeatedly coating with a very thin lacquer, probably would produce a coating too thick in proportion to the thickness of the radar steel.

All but one of the foregoing requirements of radar pulse transformer steel could be met by using an iron-alloy containing 45 to 50% nickel with a carbon content of less than 0.02%. However, for important high-power pulse transformers this alloy did not have sufficiently high magnetic permeability[a] at inductions above 15 kilogausses, although it could be used for certain other radar applications.

Relatively high permeability at inductions up to at least 17 kilogausses, and preferably higher, was needed

These representative radio and radar transformers used by the armed forces all use the special core material.

to increase the amount of energy that could be sent out from the radar antenna and keep within the rigid requirements of core size and weight. The specially-processed cold-reduced 3 to 3.5% silicon-iron alloy met this requirement better than any other known material, and its use was specified exclusively by the Armed Forces for thousands of important radar transformers.

Characteristics of Thin Silicon Steel

The maximum core loss guarantees recently published for thin electrical steel by one supplier (American Rolling Mill Co.) help the designer to predict the magnetic performance of equipment in which thin steel is used and give a rough indication of the thicknesses required for a wide range of frequencies.

TABLE I

Thickness (In.)	Frequency (Cycles/Sec.)	Induction (Kilogausses)	Grain of Sample	Tested	Core Loss (W/lb.)
0.002	100,000	0.25	Parallel	As Cut	5.0*
0.003	10,000	1	Parallel	As Cut	6.0
0.005	1,000	5	50-50	As Cut	7.0
0.007	400	10	50-50	As Cut	8.0

*Typical

The weight of thin iron that can be wound or built into a magnetic core, expressed in per cent of that of a solid steel core, is given in Table II.

TABLE II

Typical Lamination Factor for Insulated Cold-Reduced Silicon Steel Under 50 Lb. Per Sq. In. Pressure

Thickness of Steel in In.	Lamination Factor (% Solid)
0.001	75
0.002	80
0.003	85
0.005	90
0.007	93
0.013	96

The material is quite ductile and punches well. The volume resistivity of this steel is 45 microhm-centimeters, or 270 ohms per circular-mil ft.

It costs considerably more to roll a square foot of steel to a thickness of 0.002 in. than to roll it to 0.02 in., and besides, ten times as much of the thinner steel must be rolled to produce one lb. As the other processing costs also are high, the production costs per lb. for very thin steel increase in inverse proportions to at least the second power of the strip thickness. Fortunately, however, the costs are reasonable in proportion to its performance in many types of electrical equipment, and hence its application is not limited to war-time devices.

For radio generators used in World War I, thin 4% silicon steel was produced by pack rolling using hot reduction methods. The individual sheets of the pack were very often torn in trying to separate them from each other after rolling. The sheets were rough because of the large reduction during pack rolling, and consequently the lamination factor was poor. For the much thinner steel, and the much more severe requirements of thin steel in World War II, such methods of production were entirely unsatisfactory. Therefore, cold reduction of steel in coil form was investigated.

Many experimental lots of radar steel were produced in 1½-in. widths on a small two-high cold mill with rolls 5 in. in dia. and 6 in. wide. From this experience it was learned that a cold-reduced product had a tremendous advantage, magnetically as well as physically, over the hot-rolled product. So, it seemed advisable to build a new type of cold-reduction mill to produce this material.

Requirements of a modern cold-reduction mill for the production of electrical steel strip from 0.001 in. to 0.003 in. thick were found to be these:

1. The mill should be capable of producing steel in long strips suitable for the production of wound cores.
2. Strip should be produced to close thickness tolerance not only across the strip but from end to end of the coil. For temperature control during reduction the strip should, therefore, be submerged in oil.
3. The crown (increase in thickness in the center of the strip) should be very small to make possible the winding of cores from coils slit from the edges as well as from the center of the strip.
4. For economy and volume in production, the mill should be capable of doing these things:
   (a) Produce a strip wide in proportion to its thickness.
   (b) Operate at a reasonable high speed.
   (c) Give the strip a heavy reduction at each pass. For thin, hard steel this requires small work rolls with backing across their entire length. A ton of steel 12-in. wide and 0.003-in. thick is more than three miles long. It is uneconomical to take a large number of passes in reducing its thickness by, say, 50%.
5. Tension on the strip during production should be accurately controlled in order to prevent strip breakage and to improve flatness.

The available 4-high type cold mills proved incapable of meeting these requirements. Their work rolls are too large to reduce steel to the extreme thinness required. Small work rolls are needed to "bite" into the work.

Conventional type cluster mills permitted the use of small diameter work rolls but would not insure a strip of uniform thickness across its width. "Crown" in the strip would be excessive because back-up rolls would flex under the tremendous pressures required for thin rolling.

Consideration of these factors led to the installation of a Sendzimir Mill[3, 4] by The American Rolling Mill Co. in March 1944. This mill was put into operation after two months of experimental work and has satisfactorily met all the requirements listed in this section of the paper. During the last year of the war its output of 1-ft. wide strip for electrical purposes in 0.005-in. and lighter would reach one-third of the way around the world.

Pulse transformers for military uses were one of the items which made necessary the development of new core materials.

Peace-Time Applications

The new product produced on this mill is commercially available for application in television, high-frequency induction heating, sonic detection, airborne electrical power systems, and special devices that are now coming into use to assist in the long-range navigation of planes (loran), the control of aircraft position by ground-based radar (teleran), the ground control of the approach of a plane in zero ceiling weather, and anti-collision devices (lanac) as well as variations in radar equipment for many other peace-time uses.

REFERENCES

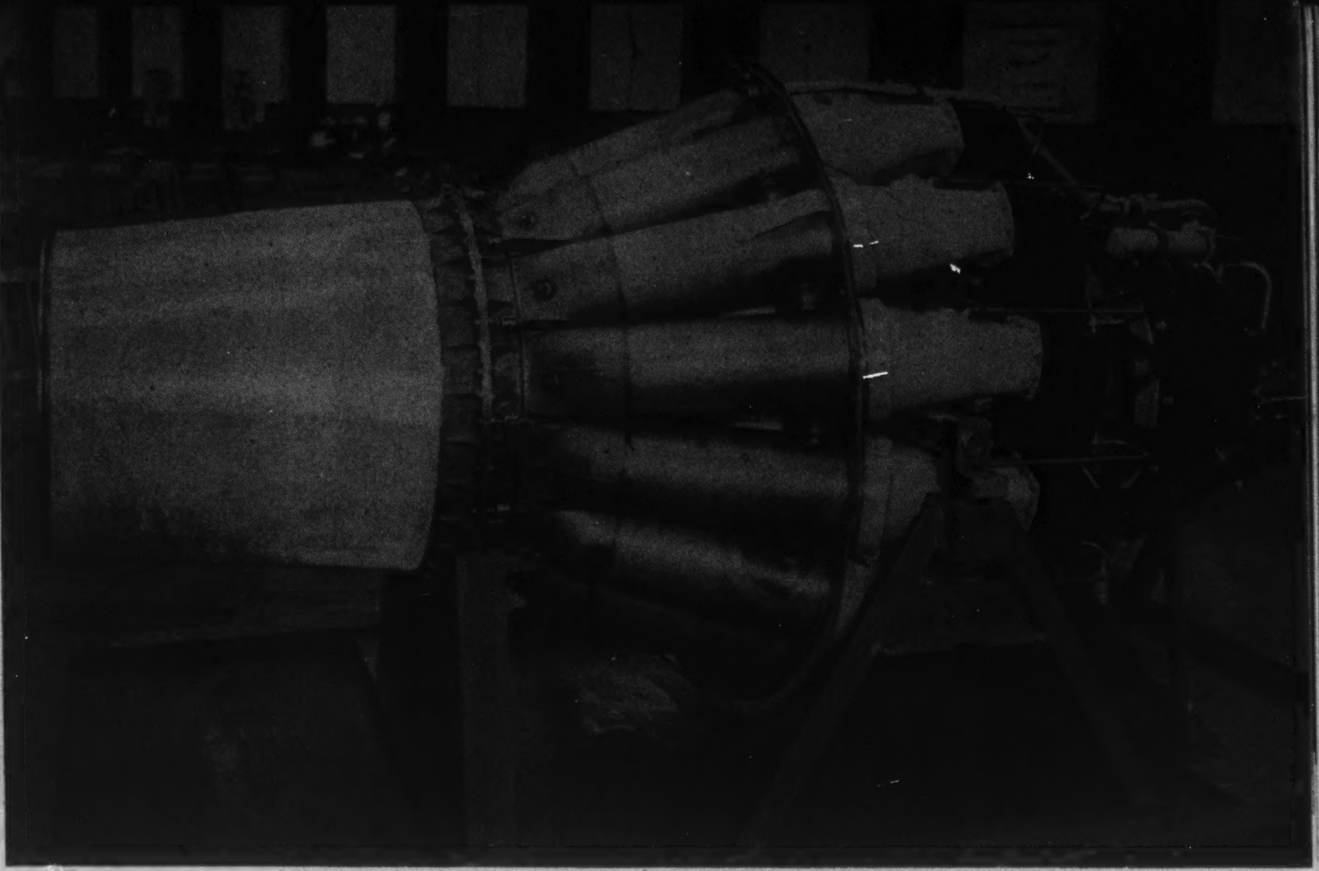
[1] *"Developments of Magnet Steels for Transformers," by C. C. Horstman and C. H. Bartlett, to be published.*

[2] *"Nickel-Iron Alloys for Magnetic Circuits," by Dr. L. C. Hicks.* Electrical Manufacturing, *January 1946.*

[3] *"Sendzimir Mill," by T. Sendzimir.* Steel, *Nov. 30, 1942.*

[4] *"The Sendzimir Precision Cold Strip Mill," by T. Sendzimir.* Iron & Steel Engineer, *Apr. 1946, pp. 53-60.*

Shown here is a completely assembled I-40 jet engine ready for installation in a plane.



Fabricating Sheet Metal Parts of Jet Engines

by **HAROLD A. KNIGHT,** *News Editor,* MATERIALS & METHODS

> **The welding of high alloy sheet metals to produce jet engine parts is typical of the problems involved in working with such high temperature materials.**

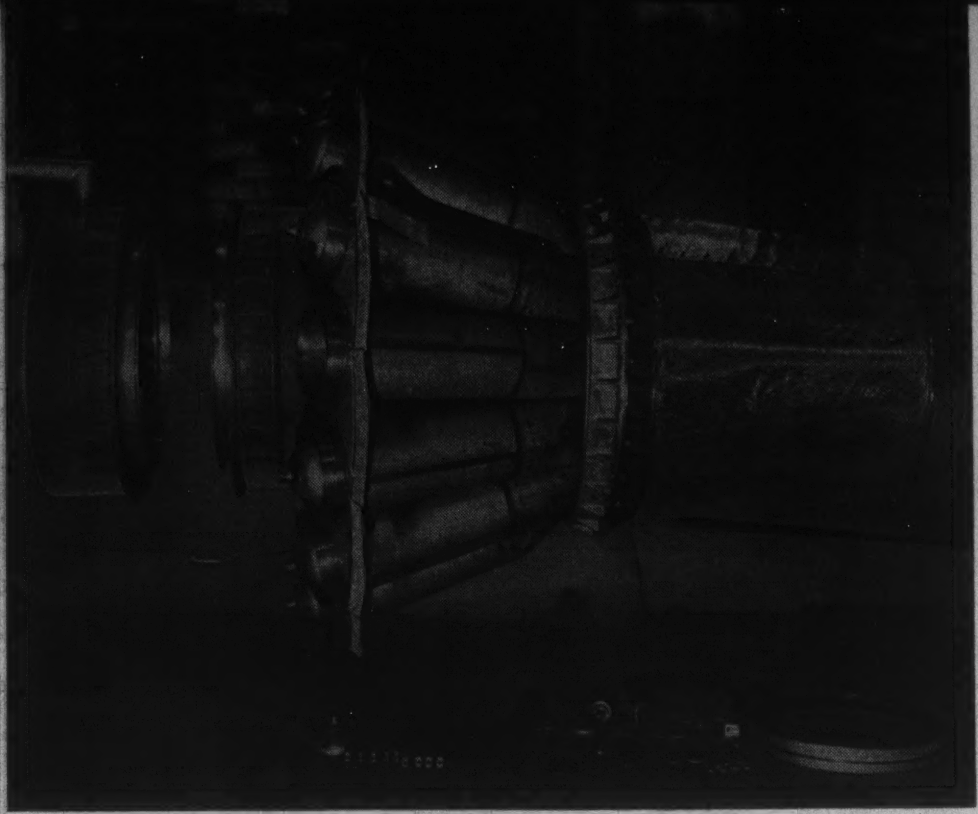
THOUGH PRODUCTION of turbines for jet aircraft engines—particularly the blades or buckets—receive most of the attention and glamor because of need of the metals to hold up to 1500 F without distortion, the fabrication of the sheet metal parts for jet engines was no less exacting. Such parts include combustion chambers, ducts and cones that provided for entrance of the compressed air, its burning along with fuel and delivery to the turbine, and then exhaust to produce thrust.

Stainless steel, usually type 347, was the preponderant material used for parts in the I-40 jet engine which powered the famous Shooting Star jet plane, with Inconel used for liners in the combustion chambers and with bronze wire screen and aluminum foil used for insulation.

The I-T-E Circuit Breaker Co., Philadelphia, played an important role in the fabrication of these sheet metal parts, working with General Electric Co. which produced the I-40 jet engine. So successful has been the company that since the I-40 was discontinued there have been further contracts, now for the Westinghouse XB-19 jet engine for the Navy. Virtually the same principles that were applied to the I-40 now rule with the newer job, with occasional shifts in processes. Thus, where a cast flange was once used a wrought ring is now employed, despite the fact that 80% of the original metal has been machined away.

There was an absence of prior knowledge in some of the fabricating problems — neither text books, technical magazine articles, data sheets nor pilot plant experience. Engineers of I-T-E traveled widely and though they picked up hints here and there with some bearing on their problems they had to solve specific problems at hand for themselves.

Welding, of course, created some distortion, especially because of the higher coefficient of expansion of stainless steels, yet in many cases tolerances were



Parts manufactured by I-T-E for the jet engine are shown in this display.

On this assembly three different types of welding were employed.

from 0.001- to 0.005-in. Stainless steel sheets, some as light as 0.022-in., came from four regular suppliers, and often more, and there were differences, even though minor, in analysis. In one assembly the liner of the combustion chamber must extend precisely 0.005-in. from the outer tube to allow the correct amount of cooling air to pass through. A wider passage would mean too much cold; narrower, too much heat.

Four Types of Welding

After considerable experimentation, the engineers chose four types of welding: Resistance seam, resisrance spot, atomic hydrogen and electric arc, picking with a nicety the type of welding best for each operation. Considerable ingenuity was used in designing a fixture for holding 14 combustion tubes in place during final assembly. Thus, though the fixture could not prevent distortion, it could keep the tube in the exact position in the assembly desired.

There were problems involved in machining the stainless steel and considerable time was consumed in securing the correct rake and angles in the carbide tool tips. Sawing the sheets and strips was not simple until they hit upon a high speed friction hacksaw (the duller the teeth the better) which traveled at 12,000 ft. per min.

It is perhaps best here to review the basic functions of the I-40 jet engine as it concerns the sheet metal parts. At the point of largest diameter, is the compressor. The outside air has been brought to the compressor through circumferential inlets on the front and back of a doublesided impeller, the inlets being screened to keep out dirt. The air is turned into the annulus of the impeller by guide vanes and a single splitter valve.

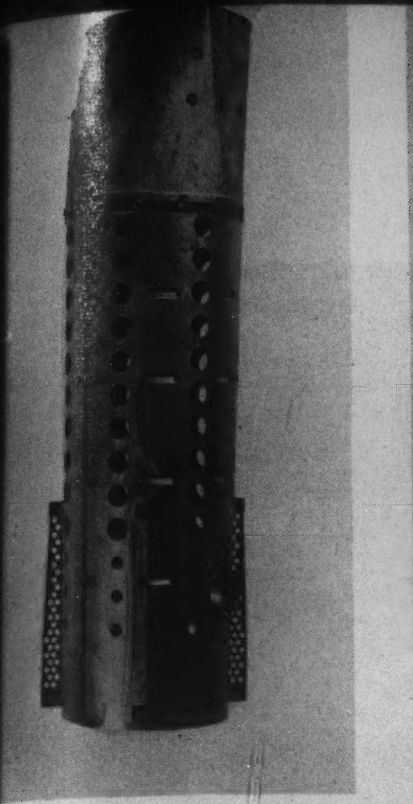
Discharge from the impeller, now air considerably condensed, enters 14 diffuser passages. At the end of each is an elbow with four vanes that turn the air 90 deg. into the compressor discharge. Compressed air is now conducted to the 14 combustion chambers, by air adapters, which carry the fuel nozzles, domes (or end caps) of the combustion chamber and two spark plugs (for starting).

Combustion is controlled by holes in the liners and outer tubes are cooled by compressor discharge air. A thin film of air travels the full length of the liners to cool at the liner ends at the turbine inlet. Exhaust from the turbine wheel is diffused in an exhaust cone to a lower velocity in the circular exhaust pipe of constant diameter, which carries the gas to a jet nozzle.

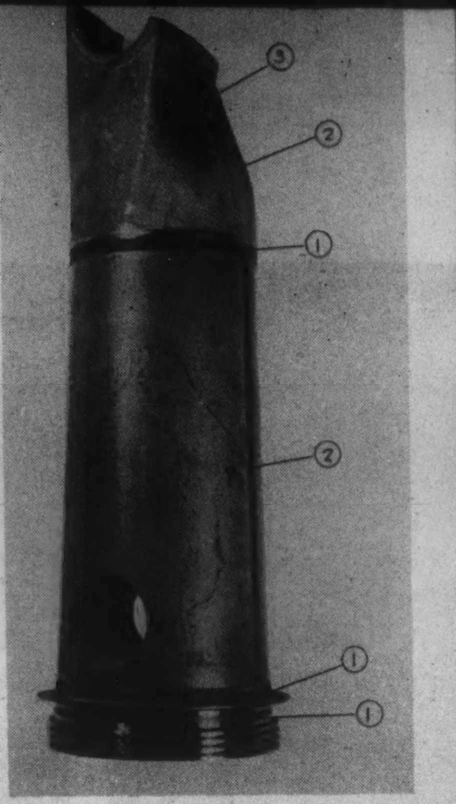
The 14 combustion chambers are arranged around the turbine (which runs the shaft that turns the impeller that compresses the original air) with their axis conical, joining at the turbine inlet to provide an annular flow of hot gas. Turbine nozzles are mounted between two rings around the discharge of the combustion chambers. At the entrance of each chamber a piston ring joint allows for expansion due to heating. The flange of the turbine bearing support (which joins to the compressor assembly) and the flange around the turbine nozzle ring (which joins to the exhaust cone) are connected by tie straps of Invar. The outer cone of the exhaust cone assembly supports an inner cone by four struts. The outer cone large front flange acts as a shroud for the turbine buckets and a small rear flange connects to an exhaust pipe.

Type 347 was the stainless steel most universally used, but on occasion types 325, 310 and 304 were used. The engineers give the analysis of the 347 stainless as follows: Chromium, 17 to 20; nickel 8 to 12; carbon, 0.10 max.; columbium, 10 times the carbon; manganese, 2.00; silicon, 0.75; phosphorus, 0.030; sulphur, 0.040%; iron, the remainder.

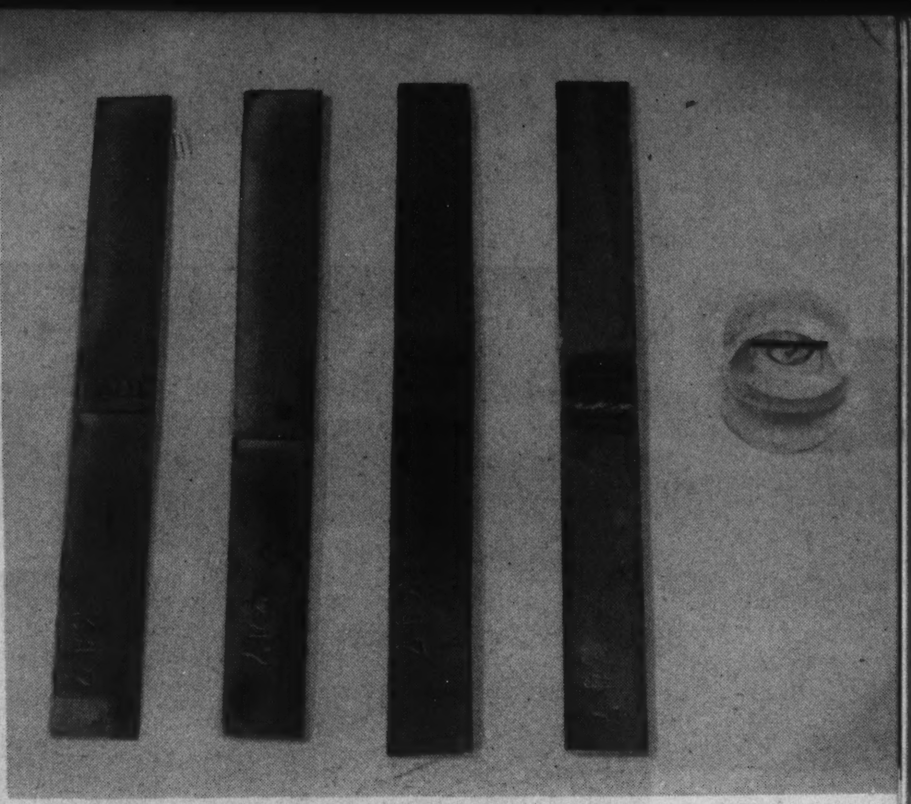
The Inconel combustion chamber liners analyze as follows: Nickel, 75.00 min.; chromium, 12.00 to 15.00; iron, 9.00 max.; manganese, 1.00 max.; copper, 0.50 max.; silicon, 0.50 max., and carbon, 0.15% max.



e inner liner of the combustion amber was fabricated of Inconel.



Three types of welding were required on this stainless steel outer tube.



From left to right are examples of seam, spot, atomic hydrogen and electric arc welding.

Welding Details

There are over 500 welded joints in the I-40 engine, most of which are in the sheet metal parts. Austenitic stainless steel alloys provide high strength and good corrosion resistance at high temperatures. Being austenitic, these alloys are non-heat-treatable and they must also be "stabilized" (note the presence of columbium). Being non-heat-treatable, there is no increase in hardness, nor loss of ductility from the heat of welding. Being stabilized, there is but very little loss of corrosion resistance after welding.

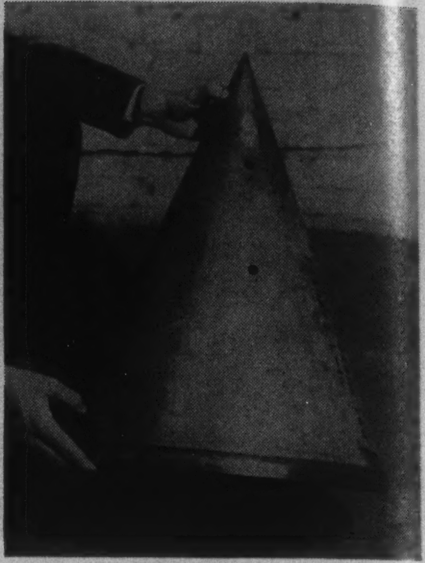
At no time did I-T-E engineers use any form of solid flux in welding stainless steels since fluxes contain fluoride. Frequent heating and cooling of parts in the jet engine will cause minute amounts of the fluoride, contained in the intercrystalline spaces, to attack the structure of the metal and cause failures in or adjacent to the weld. Coated electrode arc welding is used where sheet metal is joined to heavy cast sections.

In several places seam welding was used to join thick sections of cast 347 to much thinner sections of 347 sheets. Where weight must be saved butt welds are best in theory. However, occasionally lap welds had to be used, particularly where thin sections joined thicker ones. Had these been butt welded, stress concentration in the thinner piece would occur and possibly cause failure in service. Fusion welding would cause even greater distortion. Therefore, where the flanges were welded to the exhaust casing or the ring holders as well as to the flame tubes, a lap joint was used and the weld was generally made by resistance seam welding. This joint proved tight, had excellent strength, a minimum of distortion, and a neat appearance.

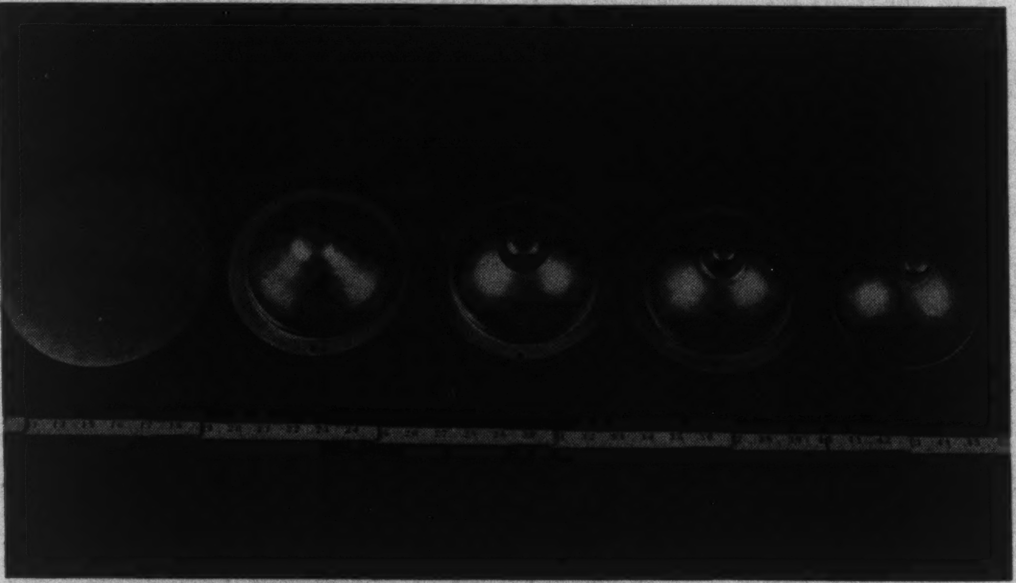
The cylindrical sheet assemblies were butt welded by the atomic hydrogen process, using special fixtures with hydrogen gas in grooves back of the weld to prevent oxidation. The grooved expansion joint member was made of centrifugally cast 347 during part of the production, but was later changed to flash welded bar stock of the same material. Both types were seam welded to the 0.031-in. sheet of the combustion chamber. Because of the deleterious effect of carbon on stainless subjected to high temperatures, no oxyacetylene welding was used at any point.

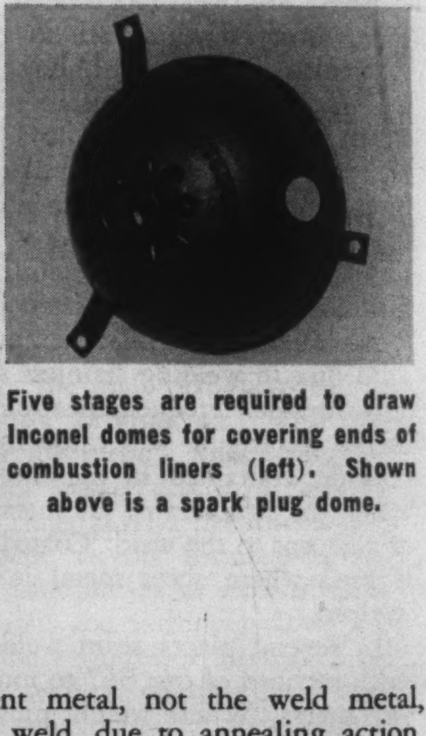
Since the atomic hydrogen welding process is fairly new the I-T-E engineers had to figure some things out for themselves. Atomic welding is so called because of

Here is a completed exhaust cone assembly with insulating jacket in position.



A forging and several sheet metal parts (left) are combined in the finished inner cone (above).





Five stages are required to draw Inconel domes for covering ends of combustion liners (left). Shown above is a spark plug dome.

a break down of the hydrogen molecules into atoms. Thus H_2 breaks down into H and H, then combines again into H_2, meanwhile forming an envelope that protects the metal surfaces. Tungsten electrodes were used and the pieces were butt welded because no filler metal was used. Thus the edges of the parent metal fuse. Prior to atomic welding the two parts were tack welded with carbon electrodes in spots and at the ends. The hydrogen backing was provided by burning hydrogen in a groove milled in the backing bar of the fixture. On thicknesses up to 1/16-in. it was possible to butt the edges up square. The welding resulted in a nearly flush joint that did not require cleaning, and with excellent physical strength. The heat expanded the metal and caused it to hump at the joints, but the hump was melted down, giving a flush weld. The a.h. welds are extremely neat, precise and efficient. When test samples are tested to destruction the parent metal, not the weld metal, fails adjacent to the weld, due to annealing action.

The atomic hydrogen welding process involves the passage of hydrogen gas through an a.c. arc drawn between two tungsten electrodes. The welding torch holds these electrodes at a 50-deg. angle, and the welder changes the distance between the tips by pressure of the hand. Hollow sleeves around the electrodes provide passageways for the hydrogen at a pressure of 1 to 5 psi., to be fed into and around the arc.

The hydrogen performs three functions:

(1) It cools the electrodes and keeps down the rate at which they are consumed, thus reducing the number of times they have to be readjusted in the holders.

(2) It transfers the heat from the arc to the exact point at which fusion is desired. This obtains when the molecular form, H_2, of the gas is fed into the arc,

is broken down by the arc into the atomic form, H, with considerable absorption of heat energy from the arc. When the atomic hydrogen reaches the metal, at the point at which fusion is to take place, it is cooled to the temperature at which it recombines into the molecular form and now it gives up the heat it has absorbed from the arc. The temperature reaches approximately 3000 F, is highly localized and enables welding to be restricted to a narrow area.

(3) It combines readily with oxygen in the air surrounding the weld area and with the oxygen combined with the material in the form of oxides. Thus the oxygen of the air does not have an opportunity to attack the welded material during the welding process and due to the fact that the oxygen is extracted from the oxides present in the metal, the hydrogen acts as a flux. The result is a clean weld with good penetration.

The length of the arc between the electrodes determines the amount of heat available for welding, the longer the arc the greater the heat. The shorter arcs are silent and after a critical length is reached, the arc "sings" with a loud penetrating hum. The nature of the material welded determines the length of the arc used. Where the coefficient of heat transmission is low, as in stainless steel, a silent arc is preferable so as not to concentrate too much heat in, and raise the temperature of, the welding area.

Air should be excluded from the back of the weld either mechanically or by feeding hydrogen to that side. The cleaning action of this gas aids in obtaining penetration and is to be preferred to strong fluxes which may attack the material and eventually cause failure.

A carbon arc or oxyacetylene flame is to be discouraged due to the danger of increasing the carbon content of the weld material, which thus reduces its corrosion resistance.

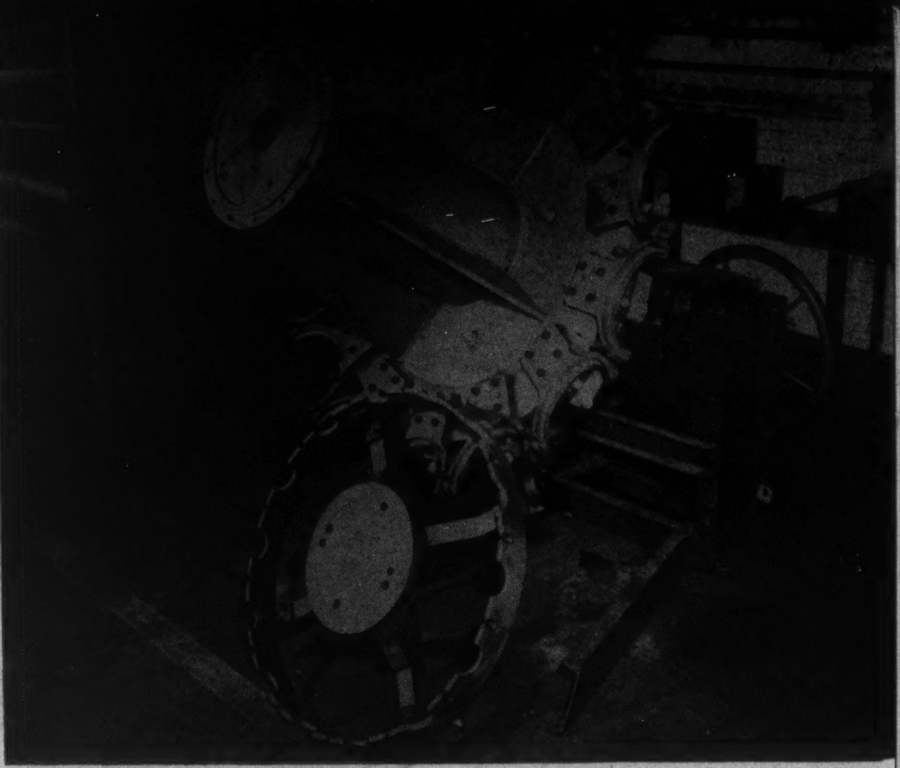
It has been estimated by the users of atomic hydrogen welding that the cost averages five cents per foot, as against double that for oxyacetylene. One company reported the use of a third of a cylinder of hydrogen per worker per day.

In the resistance seam welding the Thyratron electronic controls were used to control cycle time, rated at 200-250 kva. as against a more normal 25-50. The settings of the resistance welding machines were checked on test samples at frequent intervals as a very rigid set of standards had to be adhered to for sake of reasonable life expectancy of the engines.

Techniques with Inconel

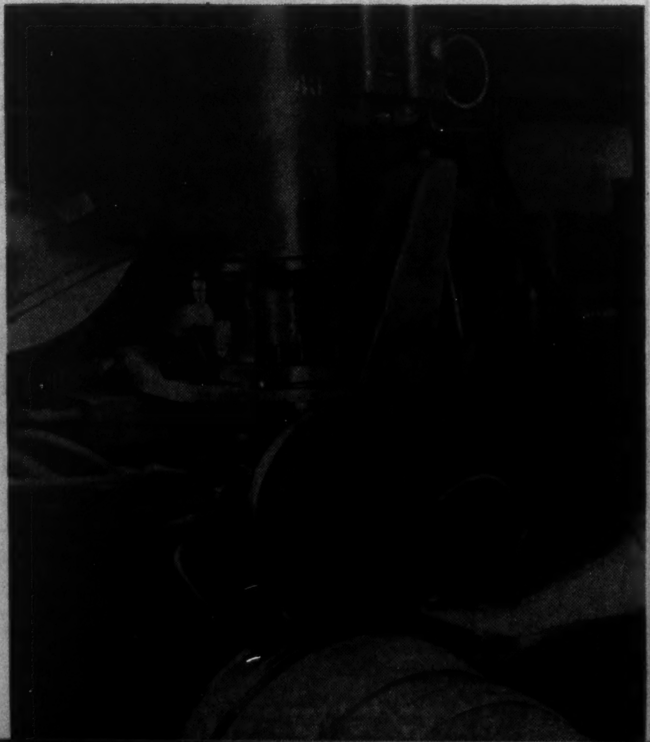
Inconel is difficult to work and must be annealed each time it is cold worked. I-T-E use a G-E roller-hearth furnace, heating up to 1950 F, in an atmosphere of precombusted city gas, water quenching to 300 F in 3 min. The furnace is automatically controlled to ±10 F.

The various cylindrical assemblies were tested for leaks with 35 lb. water pressure. Flanges were formed on Potter & Johnson automatic chucking machines. Drawing of aluminum and stainless steel parts was accomplished on HPM 200-ton triple action presses.



Distortion of flame tubes during welding is held to a minimum through the use of this special fixture.

The atomic hydrogen welding process is used to join cross-over tubes to flame tubes.



Flanges are attached to cone assemblies by seam welding.

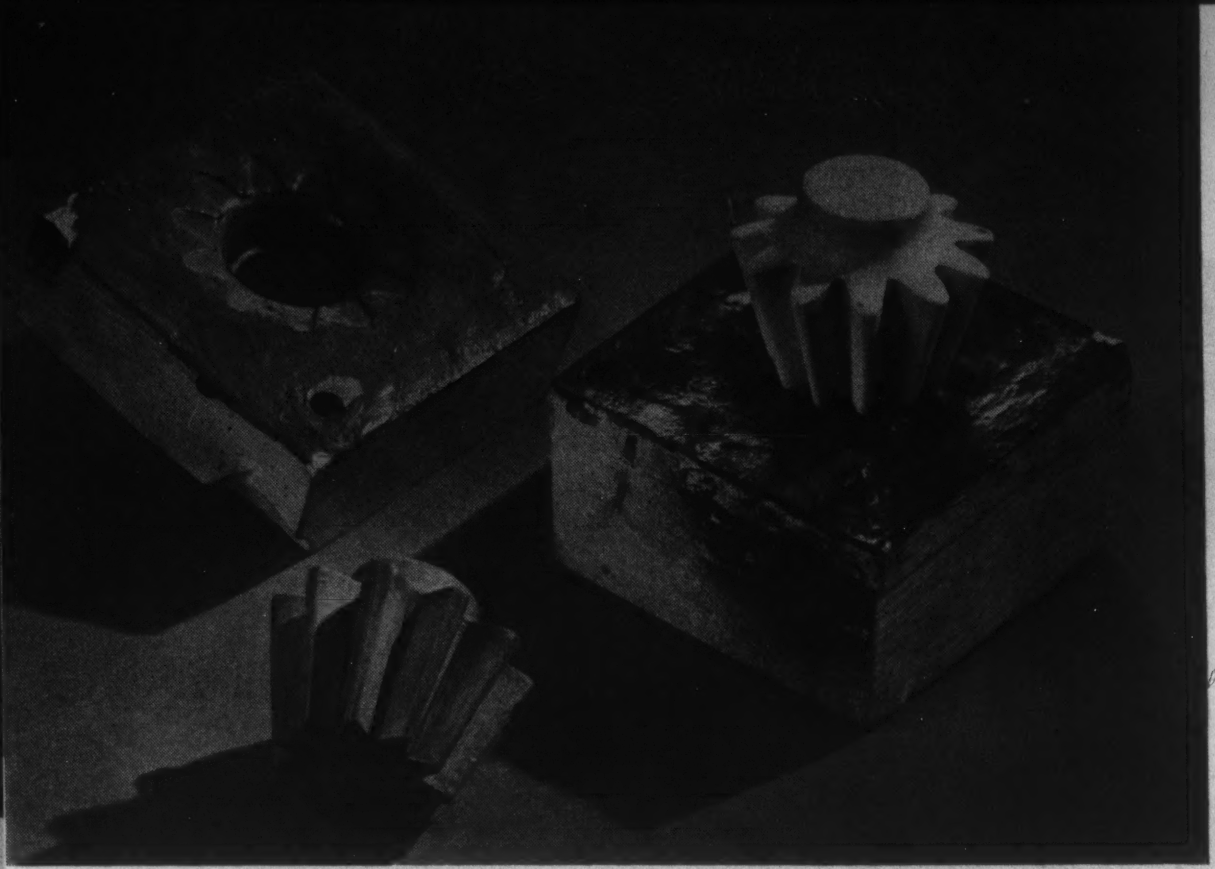


Fig. 1—Shown here are the original wood pattern, cope and drag halves of a simple two-part plaster mold and a cast resin duplicate pattern.

Patterns Made from Cast Plastics

by C. R. SIMMONS, *Durez Plastics & Chemicals, Inc.*

SINCE THE INTRODUCTION of liquid phenolic casting resins for the production of forming dies for light sheet metals, there has been a tremendous expansion in industrial applications of such resins. New applications include foundry patterns, assembly jigs and fixtures, design and working models, plating shields, masking fixtures, and duplicating machine patterns. Each of these uses presents an unusually interesting study from the angle of production speed-up as well as production economy. From the volume standpoint today, undoubtedly the greatest use of the casting resins is in the production of assembly or checking fixtures and foundry patterns. However, for the sake of clarity, this article will be limited to a discussion of cast resin foundry patterns with the inclusion of a few facts about general physical properties and handling of the resins.

There are several trade-named liquid phenolic casting resins available today. Nearly all of them are similar in physical property specifications and somewhat similar in handling. For the sake of illustration, one of these has been selected as typical in order to cite specific case histories of a few applications. This resin is described as follows: "Durez 7421A Casting Resin is a phenolic thermosetting resin in liquid form which can be cast in simple molds without the use of pressure. Cast parts have properties similar to phenolic plastic parts molded under heat and pressure. The main differences are that the cast parts are weaker mechanically and electrically but are more resistant chemically than their hot-molded counterparts. Durez 7421A will cure hard without an accelerator when baked at 200 F for 24 hr. However, an accelerator (Durez 7422) is nearly always used to increase the reaction and assure hardening in less time at a lower temperature."

The percentage of accelerator used with the resin affects the final properties of the cast piece only to a small degree but does affect to a considerable degree the baking or curing cycle. For example, the customary baking period when using 4% to 8% accelerator is 8 hr. at 140 F. If thin castings ½-in. or less in thickness are being produced, it is satisfactory to use 12 to 15% accelerator, which makes possible a baking cycle of 1 to 2 hr. at 175 F. Following are typical

Cast resins offer many advantages as materials for foundry patterns including initial cost, ease of casting and inexpensive finishing.

properties of the cast resin:

7421A + 8% 7422	Initial Curing Bake 8 Hr. @ 140 F
Shrinkage from Mold Dimension (in. per in.)	0.0025
Rockwell Hardness "R" Scale	115
Flexural Strength, psi.	12,000
Modulus of Elasticity in Flexure	5 to 7 x 10^5
Impact Strength—ft. lb. per in. of notch—Izod—ASTM	0.24
Compressive Strength, psi.—ASTM	12,000
Tensile Strength	5,000
Water Absorption	0.2-0.3%
Linear Coefficient of Thermal Expansion in. per in. per deg. F	0.00005
Specific Gravity	1.30
Dimensional Change on Immersion or Humidification	Negligible
Dielectric Strength s/s volts per mil	130
Insulation Resistance, Ohms	3 x 10^8
Volume Resistivity, Ohm-cm	1 x 10^{10}

When 5% accelerator is used, the flexural strength is reduced to approximately 8,000 psi. However, the electrical properties are improved; the dielectric strength goes to 200 vpm.; insulation resistance is 2 x 10^{10}; volume resistivity is 1 x 10^{11}. When 4% accelerator is used, the electrical properties are again raised slightly.

The particular casting resin under discussion can be cast in plaster molds, plastic molds, wood, metal, rubber, or latex molds. Handling of the resin is fundamentally the same for all types of molds, but the preparation of the molds prior to filling with the resin varies somewhat with the type of mold used. For example, when using a plaster mold the best results are achieved by giving the plaster a primer coat, such as green chromate primer TP-103, followed by a base coat of black Tygon paint, followed by a light coating with a lubricant such as a hard automobile wax. When using a lead mold, no coating is necessary, but a mold lubricant as a parting agent is recommended. When using molds of a non-acid-resistant metal, a protective coating must be used; otherwise the acid accelerator will attack the metal and cause the formation of bubbles resulting in porosity in the cast piece.

The illustrations in this article reveal the use of the casting resin for foundry patterns. Fig. 1 shows the original wood gear pattern, the cope and drag halves of a simple two-part plaster mold made from the wood pattern, and a cast resin duplicate pattern. The cast resin pattern has a few advantages over the wood original. It will not change shape or dimension with age; is not affected by atmospheric changes; does not require shellacking; can be patched if chipped; can be duplicated quickly in the same mold.

Fig. 3 shows a wood pattern, a cast aluminum pattern, a cast resin pattern, and the mold from which the cast resin part was produced. This mold has a substantial wood form into which the plaster was poured. By using wood for the outside of the plaster mold more rapid heat penetration is obtained. This insures thoroughly cured castings. Data furnished by the patternmaker on this job, J. F. Carpenter, San Antonio, Texas, reveal considerable savings in time and money in the production of the cast resin pattern when compared with the cast metal pattern. Time and material for the aluminum pattern were given as follows; 16 hr. cleaning; 3 lb. cast aluminum; 3 sheets emery cloth. Time and material for the cast resin pattern were 1 hr. sanding, 4½ hr. making and painting plaster mold and mixing resin, 5 lb. plaster, 1¾ lb. Durez resin, ¼ sheet garnet sandpaper, and a few spoonfuls of paint. Furthermore, additional cast resin patterns required only 1½ hr. of time and 1¾ lb. of Durez resin for each pattern.

Fig. 2—Cast resins are easy to machine, so there is little difficulty in producing accurate shapes.

In addition a split pattern made from the casting resin. To those who have been watching the development of the casting resin, this perfect specimen is another step forward in the application of the resin in patternmaking.

Foundries employing match plates for production require flat-backed patterns. Some have found it just as economical to reproduce 20 patterns as one. In some cases where a small muffle furnace is used for curing the casting resin, the size of the mounting board is governed by the size of the furnace. In other cases where larger batches are being made, cur-

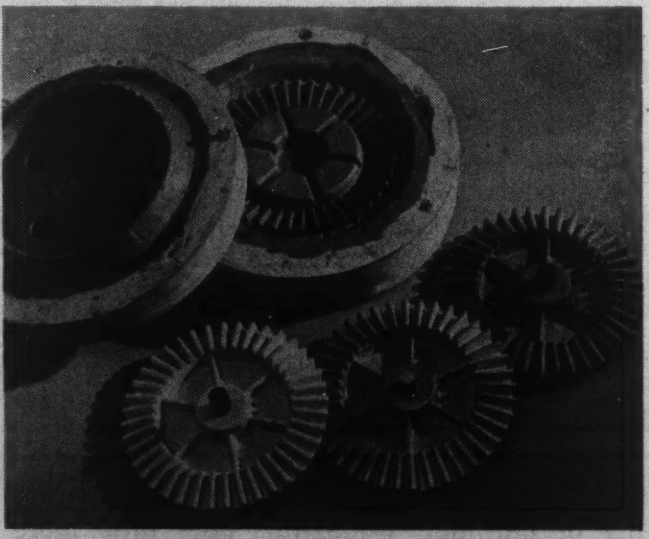


Fig. 3—Here are a wood pattern, cast aluminum pattern, a cast resin pattern and the mold from which the cast resin pattern was produced.

ing is done under infra-red lamps. The use of these lamps has resulted in even more accurate temperature control — an essential in producing good cast resin patterns.

One foundry estimated a saving of more than 50% in production cost on one job through the use of the Durez casting resin. One loose pattern had been furnished for 250 castings. As this was a difficult job to make as delivered, a core print was built up and duplicate patterns eventually made from the casting resin. The finished pattern plate, mounted and gated for production, was achieved at considerably lower than normal cost.

Fig. 4 illustrates the use of a Durez cast resin pattern with the wood original on a single mounting. Diameter at the base is approximately 12 in. Height from board at top center of the pattern is approximately 8 in. Production and delivery requirements were such that one wood original was insufficient. The cast resin duplicate was delivered by the patternmaker to the foundry in less than 24 hr. at a cost of but one-eighth that of the original wood pattern.

The use of a plaster core is illustrated in Fig. 5. In this application the lowest practical weight was desired in the finished pattern. A simple plaster core was made which allowed for reinforcement in the cast resin pattern at the selected points. This method reduces the amount of casting resin required as well as reducing the weight of the pattern.

Finishing Easily Accomplished

Patterns made of cast resin can be machined quite easily. Standard machine shop equipment can be used for such machining as is required. In general, high speeds and light cuts are best.

Special grades of tool materials are not essential. Hard bronze as well as Stellite, cemented carbide or high-speed tools should be used if long production runs are encountered but for a few pieces are not necessary.

Turning tools should be sharpened about as for brass. A clearance of 10- to 20-deg. and a slightly negative or zero rake are desirable.

Standard high-speed drills are satisfactory for holes up to 3/16 in. dia. For larger holes, specially designed drills for plastics which have highly polished flutes and maximum chip clearance are suggested.

Ground high-speed steel taps are preferred to regular standard taps but are not essential for small-quantity production. Dry-tapping is preferable.

Self-opening dies with high-speed steel chasers that extend in front and have less chamfer than standard chasers are most suitable for cutting external threads.

Standard milling machines and cutters are suitable when a milling operation is necessary. Standard equipment is also satisfactory for cutting, carving, sawing, or sanding.

The major point to consider in machining or finishing operations is to exercise care to avoid over-heating or burning. While this does little more than discolor the piece, it does have a tendency to create a weakness at the particular spot at which such burning occurs.

Sanding—Surfaces of cast resin dies can be finished by sanding, using regular wood sanding equipment. Garnet or sandpaper can be used. Fine grain paper and slow operating speeds produce the best finishing results.

Polishing—Cast resin dies can be readily polished to a glass finish by applying a mixture of 00 pumice and water to their surfaces and lightly polishing with a damp cloth. After this operation, rinsing of the die with water is necessary, after which it should be dried and polished with a polishing compound and soft buffing wheel. A highly polished surface that will minimize surface friction in subsequent metal forming and stretching operation will result. If care has been taken in the construction and preparation of the mold, the cast resin will have a satisfactory finish when removed from the mold and will require little or no finishing.

Patching—If some error or flaw must be corrected, a mixture of the material in the original casting should be prepared and used to repair defects. In the patch material, 12% of accelerator may be used regardless of amount used in original pouring. This mixture will cure overnight at room temperature.

Mounting—Where pieces are to be mounted it is good practice to allow ¼ to 1 in. of excess material at the base. This allowance is suggested as small air bubbles rising to the surface during the curing operation may make it porous and weak. Proper procedure calls for grinding or sanding this surface flat, smooth, and non-porous.

To accomplish this facing operation, it is recommended that the cast resin die be mounted, face down, on a perfectly flat table, using two straight edges, one attached on either side of the die as guides. A router can be worked over the entire die base to give a perfectly true surface. Care must be taken to use the router so that the bit moves from the die edges toward the center of the die to prevent possible chipping of the edges. Die mounting surfaces should always be backed with bases ½ to 2½ in. thick (depending on die size) of Masonite, plywood, or other composition board. Such bases should be allowed to extend ¼ to 1 in. beyond the die at the edges to make for easier handling and storing and to protect the die edges. Bases should be attached to dies with coarse threaded machine screws, holes being drilled and tapped as in metal. Machine screw number, size, and length should be determined by the size and weight of die and by the load to which it will be subjected.

Where a part is mounted for bag molding die (*i.e.*, heating and cooling employed), if the die is cast resin and base is wood, Masonite, or steel, allowance must be made for difference in thermal expansion of resin die and base material. In this case the holes in the base should be elliptical in shape so that screws can slide along. If this is not done, the base mounting or plastic die may crack or break due to strains set up by differences in thermal expansion. Thermal expansion of cast resin is 5×10^{5} in./in./deg. F. In bag molding at 180 F expansion would be $5 \times 10^{-5} \times 180$ F -80 F $= 5 \times 10^{3} = 0.005$ in. per in. On 6-ft. length, expansion would be $6 \times 12 \times 0.005$ in. $= 0.360$ in. for each 100 F rise in temperature.

This discussion of the present status of magnesium as a material for electrical batteries is of major interest in view of the serious shortage of lead.

Magnesium in Electrical Batteries

by HAROLD A. KNIGHT, *News Editor,* MATERIALS & METHODS

WHEN IT WAS ANNOUNCED recently that a British maker of all-electric automobiles (the electricity being used for power and not merely ignition) would use magnesium instead of lead as battery plates, thereby materially decreasing the weight of the automobile, attention was called to a development in the United States which has received practically no publicity. It is learned here that the newspaper statement was a bit exaggerated, the project being still in the experimental stage.

As one American expert puts it: "Magnesium batteries will not be generally useful tomorrow, but possibly day after tomorrow." Magnesium was suggested for use as the anode in batteries prior to 1925. Silver chloride was employed as the cathode depolarizer in doorbell batteries as early as 1882. The increased interest in magnesium batteries may be due to greater commercial availability of high quality magnesium. Illustrative of the interest was a paper read on the subject before the October meeting of the Electrochemical Society by Paul L. Howard, Burgess Battery Co.

Mr. Howard was asked to define the chief types of batteries for sake of clarity and understanding. A storage cell and a secondary cell are essentially the same. Such a cell is reversible and can be cycled by charge and discharge. Examples are the lead-acid storage battery and the Edison nickel-iron alkaline battery.

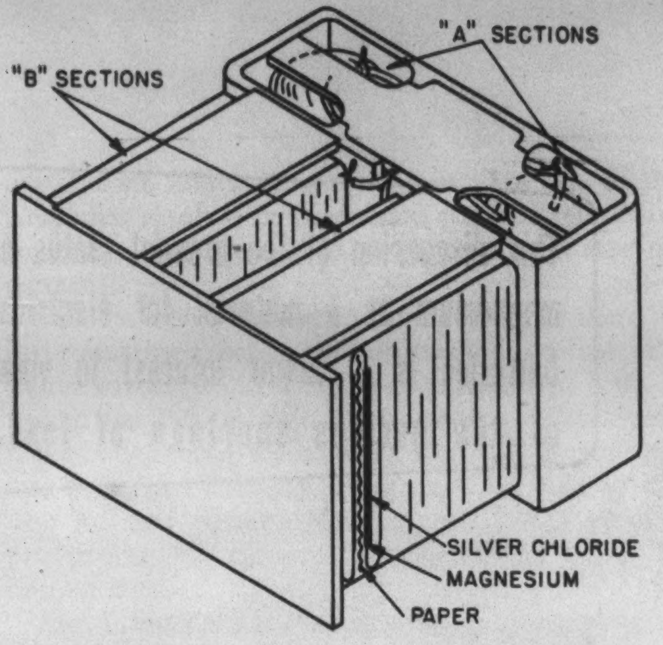
A primary cell definition may be confusing because, prior to the war, the Leland cell (copper oxide-zinc alkaline cell) and a dry cell were the only ones extensively produced. Primary cells then could not be recharged. But during the war new combinations were developed, different in characteristics. Thereafter, the primary cell, as distinguished from the dry cell, became defined as a unit which is kept free from electrolyte (*i.e.,* dry) until the time of use. Such a battery may contain a separate electrolyte chamber for storing the electrolyte until time of use or may be filled from a common source of electrolyte at time of use.

The dry cell is composed of a manganese dioxide depolarizer, a starch paste or paper separator, and a zinc negative. It includes the conventional general purpose dry batteries for high and low voltage applications and the air depolarizer cell, which is essentially the same couple.

W. S. Loose, of Dow Chemical Co., distinguishes between the various types of batteries as follows: Storage batteries are those in which the chemical condition as well as the physical state of the electrode after discharge may be brought back to the original condition simply by causing current to flow in the opposite direction; *e.g.,* by charging. They are secondary cells. There are several types in use, the main one being the lead storage battery. Primary cells are those in which the electrodes are used up chemically and must be replaced. There are two types of primary cells in wide use today, the wet cell, such as the railroad signal battery, and the dry cell, or the common flashlight type of battery. The wet primary cell has a large volume of liquid surrounding the electrodes. The so-called dry cell is actually a wet cell in which the fluid is absorbed in various materials to make a non-spillable battery.

Magnesium is used in the new primary cells. The only battery produced in this country in quantity is the silver chloride-magnesium, water-activated battery.

Magnesium in primary cells was used successfully by our armed forces. Its lightness in weight immediately commended it for use in one of the most mobile wars history has known. It gave high power where needed and was a perfect "shelf" product, dormant until required, useful, for instance, for the stranded



This cut-away view shows construction details of one type of battery using magnesium plates.

aviator to report his whereabouts by radio. Many of these war applications were where high voltage was required during a single and usually short period of time. Light weight and compactness were often essential and always helpful.

One of the war uses was for weather measuring equipment. Thus, type 2CC15 (see table: Burgess Magnesium Batteries) is used in the pilot balloon applications of the Navy. Type 2CC10 is used in the same application by the Weather Bureau. Both were dipped in water with a bulb in the socket and then hung to a large balloon which is allowed to rise at a certain rate to determine wind velocity and visibility.

By no means has the idea died with the war. The Dow Chemical Co. and several large battery makers and users are actively developing magnesium cells. There is reported a sizeable market for a light weight battery of the general type used in the war to silently push small fishing boats through the water for trolling.

The development of highly corrosion resistant alloys, the virtual elimination of pitting by very recent research, and the increased knowledge of the behavior of magnesium in various electrolytes have all led to a sharply increased interest in making use of magnesium's inherent electrochemical advantages.

To return to the original news item from Britain, light battery power for operating autos and trucks is of more interest there than in the United States because of the difference in gasoline and taxing economies. According to British records, magnesium cells were invented by Gordon in 1930 (but as stated previously, American records go back prior to 1882) and later developed into a practical and serviceable battery at the works of Callender's Cable & Construction Co., Ltd.

In their simplest form these cells were produced in three sizes, the smallest 5-in. long by 2-in. dia., consisting of a carbon tube, the anode forming the body of the cell, with three magnesium rods 4½-in. by ⅜-in. wrapped in wood-wool and inserted in the tube to form the cathode. (The British frequently confuse "anodes" and "cathodes," at least from our understanding. Americans call the electrode which corrodes —*e.g.,* the magnesium—the anode; carbon is the cathode). The cell gives an unvarying voltage of 1.5 volts during 400 hr. continuously or 1 volt at 100 milliamps drain under load. Neither temperature nor current output vary 5% until the magnesium is exhausted.

The next size, 5 by 2½ in., with 5 magnesium rods as a cathode, gives 600 hr. The third, 5 by 3 in. with 8 rods, gives the same voltage and ampere output for 1000 hr. Weights range from 8 to 15 oz. The electrolyte is merely aerated water. (Americans comment that some salt must be added; otherwise the internal resistance would be too high).

The British point out that logical application is for domestic purposes, such as for lighting in remote districts with no electrical supply; also for propelling road, rail, river and light sea-going transport. The batteries can be reversed by replacing the magnesium. One application undergoing test is a domestic refrigerator unit, including a compressor blower and prime mover, powered by 24 to 48 3-in. cells. Submersible pumps and "deaf aid" batteries are also being tested. (American comment is that most of these applications must be regarded as in the wishful thinking stage only).

Light Weight and Other Good Qualities

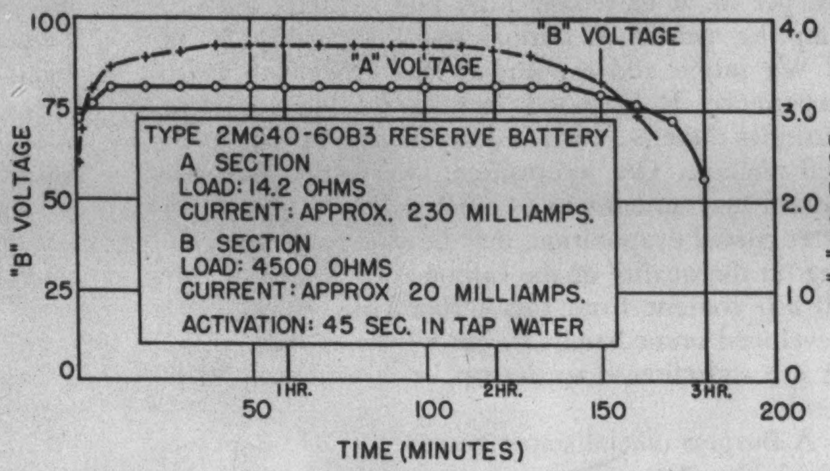
Getting back to the United States, our experts state that reasons for the intensive research work on the application of magnesium anodes to primary cells are obvious from the comparison of the properties of magnesium and zinc.

	Sp. Gr.	Electro-chemical Series	Electrochemical Equivalent, Amp. Hr./lb.
Magnesium	1.74	2.40	1000
Zinc	7.14	0.76	372

(Standard oxidation—reduction potentials, Latimer and Hildebrand, values in volts, referred to the hydrogen—hydrogen ion couple as zero at 25 C.)

Usually the magnesium cells were packed and handled dry or without electrolyte until needed. The electrolyte was added from a separate capsule, or separate compartment within the cell—or the user simply immersed the cell in water.

As regards use in propelling boats, lead storage batteries are sometimes used for fishing, even though heavy and though they remain charged for only a



Given here are the "A" and "B" voltage ratings of a battery of the same type as shown opposite.

short time. Wartime sea water batteries have shown that a simple rack supporting cathode and magnesium anodes can be immersed in sea water to supply power, which when no longer needed calls for merely raising the rack out of the water. When the magnesium plates are consumed and have given up their electrical energy, additional plates can be slipped into the rack "even easier than refilling a gasoline tank."

Other types of wet magnesium primary cells are also promising. (In one experimental type the liquid electrolyte is sealed around the electrodes, though it is pointed out that such a cell might blow up due to the fact that magnesium corrodes on contact with many desirable electrolytes, liberating hydrogen in quantity. It may be possible to overcome this difficulty eventually.) Proper selection of electrode material and composition show promise of giving satisfactory shelf life, high potential and uniform voltage during discharge. Magnesium cells may be advantageous over wet zinc cells because of higher voltage and greater uniformity of discharge.

Another battery field in which magnesium may become very useful is in so-called dry cells for flash light, radio and communications applications. Experts say that it is very probable that magnesium primary cells eventually will be on the market with lighter weight, higher voltage and greater uniformity of discharge than are found in present day batteries. However, such type of batteries would seem subject to the same criticism of that mentioned concerning the magnesium primary cells in which a liquid electrolyte is sealed around the electrodes.

Silver Chloride Magnesium Battery

During the war the C. F. Burgess Laboratories, now the Burgess Battery Co., developed and put into production a silver chloride-magnesium water activated battery, made up of cylindrical or rectangular form, depending on the application. The cells may be assembled into batteries of low voltage units or high volt "B" units.

The maker of these batteries lists five features: (1) Light weight and small size. It is shipped and stored without electrolyte since water is used as the electrolyte. (2) It is maintained dry in a hermetically-sealed container until time of use, thus having an infinite shelf life under all conditions of temperature and humidity. (3) At the time of intended use, the battery is removed from the container and immersed in tap or sea water for activation. It may now be either discharged by removing it from the water and letting it stand in air or be in continued immersion in the low voltage types throughout the discharge. This eliminates the necessity of having an additional electrolyte chamber to carry electrolyte with the battery, as with other types of reserve batteries. (4) The individual cell voltage under load averages around 1.5 volts. After the battery has been activated and placed on discharge, it will operate as low as —40 F without serious reduction of capacity—also at higher than normal temperature. (5) There is a constancy of discharge voltage throughout, giving much more stable operation of equipment than that obtained by the conventional sloping discharge curve.

Technically, the battery consists of the silver chloride depolarizer, produced by an entirely new process developed by the Burgess Battery Co., and magnesium sheet. These two elements are separated by a highly absorbent paper.

Comparisons with Conventional Cells

In one comparison, a magnesium battery of Burgess has the same capacity under continuous discharge as the conventional dry cell with only one-third the weight, or as 260 gm. compares with 681 gm. This is Burgess type 4 MC 96, 2-3/10 by 2 by 3 in., which has an equivalent capacity on continuous drain to the normal 6-v. dry cell battery of the Radio "A" variety, the latter being 2⅝ by 2⅝ by 4 in.

Another interesting set-up is a combination of a 3.2-v. "A" and 90-v. "B", 2⅝ by 2-13/16 by 1⅞ in., weighing 225 gm., activated. This delivers 200 milliamps on the "A" and 30 ma. on the "B" for 2½ hr.

Another is a 3-v. unit, 2⅞-in. in dia. and 3⅝-in. long, weighing 360 gm., activated, which will deliver 38 am. for 9 min. to 2.2 end volts, a type used as a high rate battery. These are essentially reserve batteries for "one shot" operation, and are not designed for intermittent service. Primarily, they are used where light weight, minimum space and high power are essential, or where emergency units with infinite shelf life prior to use is necessary. The output is 12 amp.

hr. per lb. at extremely high rate discharges and 23 amp. hr. per lb. at normal and low rate discharges.

We might add a point at this time from British experience. It is stated that in testing magnesium batteries there is a certain delay before the cell reaches full voltage. On intermittent work this induction period may amount to as much as 30 to 40 sec. and, after partial evaporation, may be still greater, depending on the quality of the carbon tube. By eliminating all ash content from this carbon, the full emf. was developed immediately, except when the cell has been in use and allowed to dry up, or when first put into service.

A Burgess official states, however, that the only lag which they have in their unit is the time necessary to wet the battery during the activation. There is a drop in voltage immediately upon adding to the load. Or if the load is on at the time the battery is immersed in water for activation, the same type of curve is obtained.

Development work along the lines of magnesium for batteries has had very little publicity, states W. S. Loose, director, Laboratory Development, Magnesium Laboratories, Dow Chemical Co. "It has been intensive," he continues, "and we believe it is approaching successful results. While magnesium cannot hope to enter the secondary battery field, the development of improved primary cells, using expendable magnesium anodes, may reduce the need of storage batteries. Magnesium may replace a lot of zinc in dry cells, as it is now doing in the cathodic protection of pipelines," he concludes.

H. E. Haring, electrochemist of Bell Laboratories, discussed Bell's past activities and future expectations at the recent Toronto meeting of the Electrochemical Society. Whereas Messrs. Mullen and Howard have shown that the "roll-up" type of silver chloride-magnesium battery is superior to many other kinds of battery for certain low-power, short-time uses, Haring believes that this restricted sphere of usefulness could have been broadened materially by closer adherence to basic principles of electrochemical design. Stated briefly, these principles are:

(1) The ratio of available electrolyte to active material should be sufficiently large to permit maximum operating efficiency.

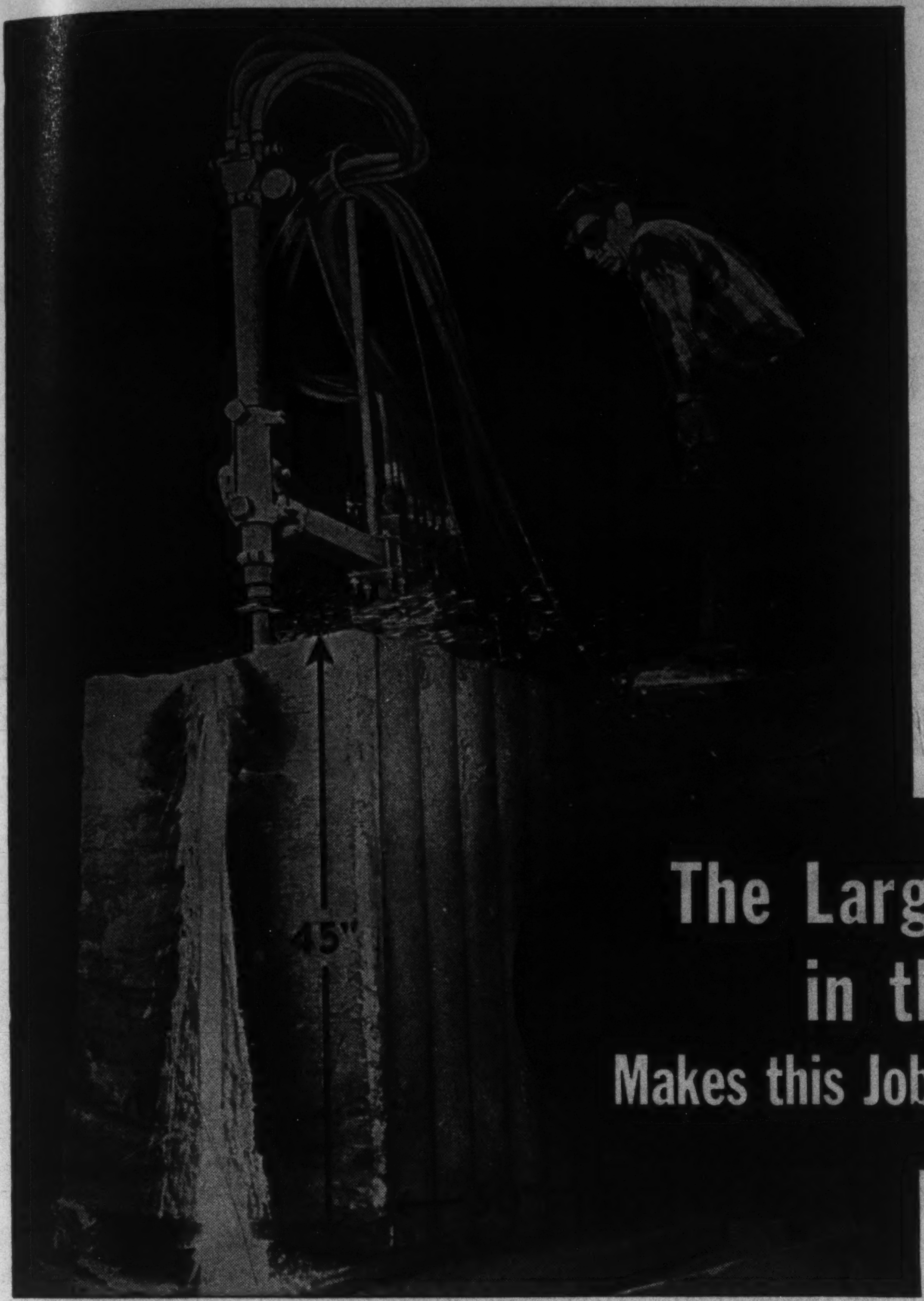
(2) The ratio of active material to structural material should be as large as possible, particularly if a maximum output per unit of weight or volume is desired.

During the war years Bell Laboratories developed magnesium/seawater/silver chloride batteries which differ radically from all other types of primary battery. Conceived at the laboratories prior to the war, this project subsequently was endorsed by the National Defense Research Committee and in cooperation with the Navy intensively pushed to a highly successful conclusion. A variety of models went into quantity production ranging in weight from 1 oz. to several hundred lb.

According to Haring, the discharge curves presented by Mullen and Howard indicate a "come-up" time which is much too slow for many applications. It should be possible to improve this situation by slight modifications based on electrochemical principles, Mr. Haring concludes.

Magnesium Batteries

General Characteristics				Discharge Characteristics		
Type	Volts	Wgt. Dry (Approx.)	Wgt. Wet (Approx.)	Voltage	Current	Time
4 mc 96	6	190 gm.	260 gm.	6.3	1.6 A	1 hr. to 5.5 v.
4 mc192	6	280 gm.	400 gm.	6.3	1.6 A	2 hr. to 5.5 v.
4cc42	6	74 gm.	110 gm.	6.2	0.7 A	65 min. to 5.8 v.
4cc25	6	60 gm.	75 gm.	6.3	0.5 A	60 min. to 5.8 v.
4cc12	6	27 gm.	40 gm.	6.3	0.2 A	30 min. to 5.8 v.
3K1	3	15 gm.	20 gm.	3.0	7.0 A	Flash current for 20 sec. duration
1cc18A	1.5	20 gm.	25 gm.	1.55	0.3 A	66 min. to 1.4 v.
2cc15	3.1			3.1	0.38 A	55 min. to 2.9 v.
2cc15 fuse	3.1	23 gm.	28 gm.	3.1	1.00 A	18 min. to 2.9 v.
2cc10	3.1	22 gm.	26 gm.	3.1	0.32 A	36 min. to 2.9 v.
2cc7.5	3.1	8 gm.	12 gm.	3.1	0.32 A	28 min. to 2.9 v.
1cc7.5 plain	1.5	3 gm.	5 gm.	1.35	1.00 A	5 min. to 1.34 v.
30B4.5	45	74 gm.	100 gm.	45	34 ma.	150 min. to 36 v.
30B3	45	70 gm.	90 gm.	45	105 ma.	38 min. to 36 v.
30B1.5	45	45 gm.	60 gm.	45	8 ma.	190 min. to 39 v.
2mc40-60B3	3 v. "A" 90 v. "B"	175 gm.	225 gm.	"A" 3.2 "B" 92	210 ma. 20 ma.	2.5 hr. to 2.7 v. 2.5 hr. to 75 v.
18mc510 (2-9mc510 sections)	27	3 lb. ea. sec.	4 lb. wet ea. sec.	27	4.25 A	2 hr. to 24 v.
4cc167	6	350 gm.	420 gm.	6	10. A	15 min.
4cc143	6	350 gm.	420 gm.	5.6	25	4 min.
4cc200	6	1 lb. 9 oz.		6.0	1.8 A	2 hr.
5cc133	7.5	300 gm.	360 gm.	7.5	8 A	12 min.
4cc195	6	2 lb.		6.0	1.6 A	2 hr.
4-2cc304	12	1200 gm.		12	40 A	7 min. to 8.8 v.



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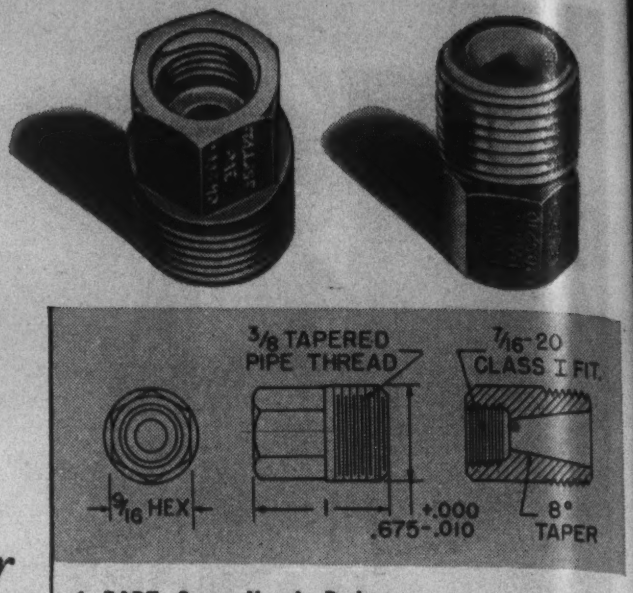
permits wide range of design for parts that must be strong . . . hard . . . and corrosion-resistant . . . even at high temperatures



1. PART: Spray Nozzle Body

Machining this part from bar stock is more expensive than precision casting it from corrosion-resistant HASTELLOY alloy C.

The HAYNES precision casting process now makes it possible for engineers to specify alloys with unusual engineering properties—such as HAYNES STELLITE alloys, HASTELLOY alloys, or the recently developed high-temperature alloys. Improved designs are possible because parts can be engineered for performance rather than for convenience of fabrication.

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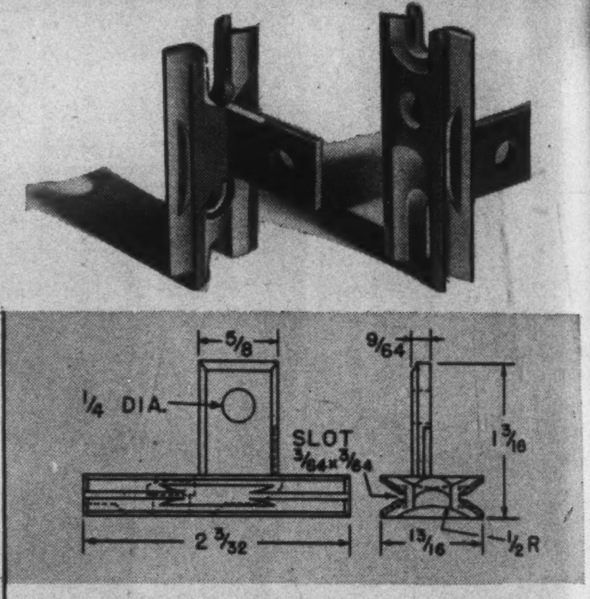
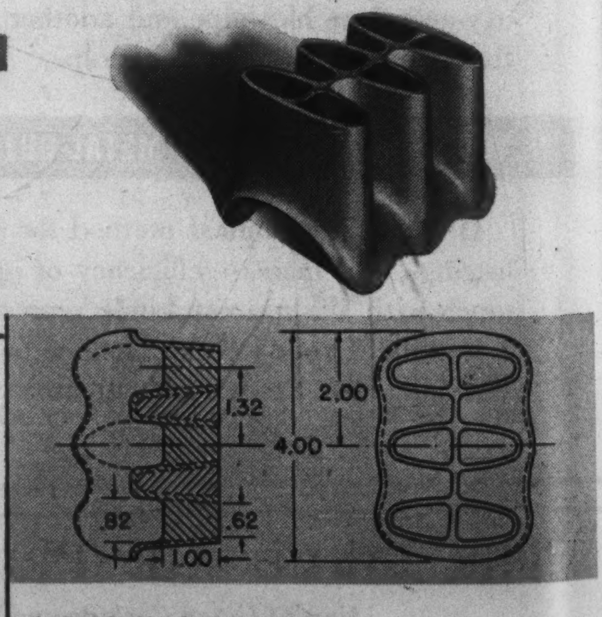


2. PART: Reciprocating Slide

Precision casting this slide, used in cloth-cutting machinery, from HAYNES STELLITE alloy No. 6 saved 42 machining operations.



3. PART: Jet Outlet Nozzle

This part is precision-cast of HAYNES STELLITE alloy No. 21 because it did not hold its shape when fabricated from sheet metal.

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MATERIALS & METHODS MANUAL

21

This is another in a series of Manuals on engineering materials and processing methods, published at periodic intervals as special sections in Materials & Methods. Each of them is intended to be a compressed handbook on its particular subject and to be packed with useful reference data on the characteristics of certain materials or metal forms or with essential principles, best procedures and operating data for performing specific metalworking processes.

Nickel and High-Nickel Alloys

by DR. NORMAN E. WOLDMAN

Nickel and its various alloys have come into increased importance during recent years because of their many desirable characteristics, not the least of which are their high resistance to heat and corrosion. In this manual, Dr. Woldman discusses the various wrought nickels and nickel alloys, and reports on the best and most up-to-date practices for welding, cleaning, finishing, machining and otherwise processing this important group of engineering materials.

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Materials & Methods, December 1946
(Published since 1929 as Metals and Alloys)

This 17-ft. hydrofluoric acid regenerator column has a minimum of 1/16-in. of Monel lining the inside diameters. The two grids are also of Monel. (Courtesy: A. O. Smith Corp.)

Introduction

In design, construction and manufacture of parts and equipment for industrial use the design, materials and production engineer are faced with the problem of selecting the material best suited for the purpose intended. The material must have the desired chemical, physical and mechanical properties to give satisfactory life and performance in service; be economical; and, must be available in the necessary forms and condition for processing or fabrication. Further, the ease with which the material can be machined, stamped, spun, drawn, forged, heat treated and otherwise processed determines overall cost of the finished product.

In many applications only certain materials can be used owing to their special and unusual properties. In other cases more costly alloys may be preferred over the cheaper alloys for increased service life and better performance, thus overbalancing the original high cost of the material. It would be quite a simple matter to select the strongest metal, or the hardest or the toughest or the most corrosion resistant material. However, when the material has to withstand some unusually destructive set of service conditions, then it is a question of searching for that metal or alloy with the most desirable combination of essential qualities.

The economic importance of corrosion in industry is commonly known and generally acknowledged to have in many processes an important if not dominant part in the commercial success of the process. Therefore, where corrosive materials are produced or used in the production of other materials, it has been the part of economy to seek materials which will serve usefully without excessive costs due to replacements and without danger of contamination of the products.

In this manual an effort is made to give condensed and specific information regarding the composition, properties, fabrication and uses of nickel and the nickel-base alloys containing over 50% nickel so that he can become familiar with the characteristics and possibilities of these alloys and can determine which of the materials are properly and best suited for his particular design and service application. For more detailed information the reader is referred to the manufacturers of these alloys or to their publications.

Nickel is one of the most important metals in modern engineering design and construction. Its great demand in many fields of application is indicated by the fact that it ranks ninth in the world's consumption of metals. Nickel is a white, malleable, non-corrodible metal, having high strength, relatively high heat conductivity and good heat resisting properties. These characteristics make nickel desirable for many uses where other metals are not suitable.

As an alloying element in iron, steel, copper and aluminum, the improvements imparted to the alloys by nickel are well recognized and established. In small percentages it toughens and strengthens iron, steel and copper alloys. It makes aluminum alloys maintain strength at elevated temperatures. In larger quantities, especially when combined with chromium, it makes iron and steel corrosion-and-heat resistant. Nickel also imparts special magnetic properties to iron and has a marked effect on its coefficient of expansion.

The high nickel alloys, i.e., the nickel-base alloys containing more than 50% nickel are in a class by themselves as they have physical and mechanical properties not readily duplicated by other base alloys. These alloys are tougher, stronger and harder than copper and aluminum alloys, and are as strong as alloy steel. They are highly resistant to corrosion to most of the normal and special corroding agents found in industries, and they resist oxidation and scaling at elevated temperatures. All the high nickel alloys are characterized by exceptional high corrosion and heat resistance, good strength, toughness and high ratios of strength to ductility in all conditions of mechanical and thermal treatments. Some of these alloys respond to a precipitation-hardening heat treatment for maximum properties. All, with few exceptions, can be cold-worked with subsequent increase in strength and hardness.

Fabrication methods in general are more similar to those used for steel than for the softer nonferrous metals. High nickel alloys can be readily hot-worked, but must be done in sulfur-free atmospheres because of the embrittling effect of sulphur upon nickel. During cold working operations, as deep drawing and spinning, more frequent anneals are required between operations to remove the rapid hardening and stiffening effect of the cold work. For either hot or cold working, heavier equipment is required than for steel. These alloys are not difficult to cut, but their high strength and ductility call for machining procedures somewhat different in detail from those employed for metals and alloys not so tough. Several of the alloys have been modified in composition to make them more free-cutting and also suitable for automatic screw machines. These alloys can be readily joined to similar metals or dissimilar metals by normal procedures of soldering, brazing and welding.

Nickel and most of the high nickel alloys are available practically in all commercial forms with only a few exceptions depending on the alloy composition. They can be supplied by the mills in hot or forged bars, rods and plates; cold rolled bars, rods, sheet, strip and wire in various tempers; seamless tubing, forgings and castings. Some of the alloys are true casting alloys and are supplied only in the as-cast condition. Some of the alloys are supplied clad to steel either on one side or on both sides. Practically all are supplied also as welding wire and rod.

Because of their combination of excellent strength and high corrosion resisting characteristics, the high nickel alloys are found in extensive use for equipment in handling, transporting and storing acids, alkalis and other corrosive materials used in the production of steel, oil and coal products, paper and pulp, paint and varnishes, drugs, explosives, rubber, soap, textiles and commercial chemicals. They are used for equipment for food processing, milk and dairy products, laundry and dry cleaning, leather tanning and pickling. They find wide use for architectural trim, marine applications, aircraft and railroad service. Agitator units, autoclaves, tanks, kettles, evaporators, mixers, pickling vats, heat exchangers, coils and pipe are just a few items listed to illustrate the type of equipment using these high nickel alloys.

Their high heat resistance and ability to maintain strength at elevated temperatures make these alloys in great demand for parts and equipment requiring resistance to oxidation, creep and scaling. Such equipment can be listed as heat treating boxes, carburizing and nitriding containers, furnace parts and aircraft engine exhaust manifolds. Some of these alloys have exceptional magnetic properties and other properties making them useful for electrical instruments and equipment. Several of the wrought alloys are used for springs especially in applications at elevated temperatures where failures are ordinarily caused by corrosion or heat.

Classification of Available Materials

The mill products of the high nickel alloys have been classified by Mudge into six main groups according to their composition. The kind and quantity of alloying element or elements added to the nickel determine into which group the alloys belong. This classification is shown in Table 1:

The proprietary trade name alloys which fall into the above six groups and their nominal compositions are shown in Table 2. The five grades of nickel, the six Monels, and the one grade of Inconel are trade names of the International Nickel Co., Inc. The four Hastelloy alloys are trade names of products of the Haynes-Stellite Co. The Illium alloy is manufactured by the Burgess-Parr Co. However, the 60 nickel, 15 chromium type of alloy comprises a large number of alloys under specific trade names of their manufacturers. Some of these alloys are Midvaloy BTG by Midvale Steel Co., B & W 700 and B & W 701 by Babcock-Wilcox Co., Firearmor A and B by Michiana Products Corp., Amsco F5 and F6 by American Manganese Steel Co., Thermalloy A by Electro Alloys Co., Tophet C by Wilbur B. Driver Co., Chromel C by Hoskins Mfg. Co., Nichrome by Driver-Harris Co., and many others.

Another group of alloys of the 80 nickel, 20 chromium type have been developed particularly for electric resistance wire and heating elements at service temperatures up to 2100 F. They have specialized application and will not be discussed here further. But their names are mentioned here for reference purposes only, since they are high nickel alloys and have the composition of approximately 80% nickel and 20% chromium. These alloys are Chromel A by Hoskins Mfg. Co., Nichrome V by Driver-Harris Co., Tophet A by Wilbur B. Driver Co., and Alray A by Alloy Metal Wire Co.

Still another group of nickel-base alloys are the nickel-iron alloys of 70 to 85% nickel content used as electromagnetic materials in electrical and magnetic equipment. These alloys have high magnetic permeability after proper heat treatment. They are known as the Permalloys of Bell Telephone Laboratories and Mumetal of Allegheny-Ludlum Steel Co. These alloys were developed for special applications, and will not be further discussed in this paper.

Nickel

There are five specific grades of commercial nickel, namely, "A" nickel, "D" nickel, "E" nickel, "L" nickel, and "Z" nickel, each having a definite chemical composition for definite properties and applications. The commercially wrought form of nickel is known as "A" nickel and is generally referred to as "nickel" to distinguish it from electrolytic nickel (99.95% pure) and from nickel-base materials containing minor quantities of alloying elements which are added to impart special properties. "D" nickel and "Z" nickel are two such special alloys, but "L" nickel is a low carbon grade of "A" nickel commonly known as "carbon-free nickel" of 0.02% maximum carbon content, used particularly for difficult deep drawing and spinning operations.

"A" nickel is the basic material and is the commercially pure, malleable material having an average nickel content of 99.4% which includes less than 1% cobalt which is counted as nickel because its effect upon the significant properties of nickel is slight. The cast form of commercial nickel contains about 1.5% silicon to improve its fluidity and castability. Wrought nickel combines excellent mechanical properties with good corrosion resistance. It responds readily to all commercial fabricating processes and practices, and can be joined by all regular methods of soldering, brazing and welding. Its mechanical properties are similar to those of mild steel. It resists hydrogen chloride, chlorine, caustic soda, oxidation and scaling, retains its strength to an excellent degree at elevated temperatures, and retains its ductility, toughness and strength at sub-zero temperatures. In fact the yield point and elongation are 40 to 50% higher at 300 F than at room temperature. It has excellent corrosion resisting properties and is free from season cracking and other forms of stress corrosion in atmospheric conditions.

Commerical nickel is available as plates, sheets, strip, tubes, bars, rods, wire and other mill forms. It is also available as sand, centrifugal and precision castings, wire cloth, bolts, rivets and many other specialties. It is used where strength combined with resistance to corrosion and oxidation are required. The chemical, soap and allied industries use rolled nickel for the construction of evaporators, jacketed kettles, tanks, heating coils and other processing equipment. Support wires and other parts of incandescent lamps and hot cathodes in radio tubes are made of nickel.

"L" nickel has essentially the same nominal composition as "A" nickel, with the exception that the carbon content is kept to a minimum (0.01 to 0.02%). It is softer than the regular grade and does not work harden as rapidly. Its yield strength and elastic limit are lower than "A" nickel, and the ductility is greater. For these reasons the "carbon-free" grade of nickel is often preferred for the fabrication of spun or stamped articles. It is particularly used for applications which require resistance to oxidizing atmospheres up to 2000 F, such as nickel crucibles and combustion dishes. This grade is produced in all commercial forms, but chiefly as cold rolled sheet and strip.

"D" nickel and "E" nickel conform generally to the composition of "A" nickel, the most important difference being the inclusion of about 4.5% and 2.0%, respectively, of manganese replacing a like amount of nickel. The manganese addition increases the metal's resistance to atmospheric attack and to sulfur compounds at elevated temperatures. The mechanical strength at normal and elevated temperatures is higher than that of "A" nickel. "D" nickel is produced and used chiefly in the forms of rod, wire, and strip. It is used extensively for spark plug electrodes, ignition tubes, radio tube grid wires, and for marine boiler refractory bolts. "E" nickel wire finds use for furnace lead-in wires and support wires in incandescent lamps.

"Z" nickel is a wrought, age-hardenable alloy containing approximately 93.5% nickel, has good strength, hardness, and

TABLE 1 — CLASSIFICATION ACCORDING TO COMPOSITION

Group I.	Nickel 93.5 to 99.5% nickel (and a maximum of 4.5% manganese)
Group II.	Nickel-Copper 63 to 70% nickel, 29 to 30% copper
Group III.	Nickel-Silicon 85% nickel, 10% silicon
Group IV.	Nickel-Chromium-Iron 54 to 78.5% nickel, 12 to 18% chromium, 6 to 28% iron
Group V.	Nickel-Molybdenum-Iron 55 to 62% nickel, 17 to 32% molybdenum, 6 to 22% iron
Group VI.	Nickel-Chromium-Molybdenum-Iron 51 to 62% nickel, 15 to 22% chromium, 5 to 19% molybdenum, and 6 to 8% iron

high resistance to corrosion. It work-hardens much more rapidly than "A" nickel, and is much harder and stronger than "A" nickel even prior to heat treatment. Heat treatment does not destroy the effect of cold-working during fabrication, but supplements it to produce unusually high mechanical properties. The heat treatment is of the precipitation-hardening type and is carried out at temperatures below the annealing temperature. Tensile strengths as high as 240,000 psi. and hardnesses up to Rockwell 45 C can be obtained for heat treated spring temper wire of small diameter. "Z" nickel possesses the ability, characteristic of all nickel-base alloys, to retain its impact strength and ductility at temperatures down to that of liquid air.

"Z" nickel is commercially available in the form of hot-rolled or cold-drawn rods, cold drawn wire and cold rolled strip, tubes, and forgings. It is suitable for such applications as coil and flat springs, diaphrams, radio antennae, safety tools, extrusion dies for plastics, pump parts and other applications requiring a material combining high corrosion resistance with unusually high mechanical properties.

Nickel-Copper Alloys

The second class of commercial nickel-base alloys are the so-called Monel type containing approximately two-thirds nickel and one-third copper. There are six grades of such alloys, all developed by the International Nickel Co. and known under the trade names of Monel, "R" Monel, "K" Monel, "KR" Monel, "H" Monel and "S" Monel. The nominal compositions of these alloys are shown in Table 2 and their typical physical and mechanical properties are shown in Tables 3, 4, 5, and 6. These alloys are all strong, tough, rustproof and highly resistant to corrosion.

Monel is the most important alloy in this group. Its combination of high strength, ductility and excellent resistance to corrosion makes it a general purpose rather than a specialized alloy. Monel is more resistant than nickel under reducing conditions and more resistant than copper under oxidizing conditions. It cannot be hardened by heat treatment, but its strength and hardness can be increased by cold working. The properties of Monel are not much effected by temperatures up to 750 F. Short time tensile tests show a practically straight line drop in tensile strength from 70,000 psi. at 800 F to 15,000 psi. at 1500 F. Creep stress required to produce 0.1% elongation in 1000 hr. is 31,000 psi. at 750 F, 24,000 psi. at 800 F, and 12,500 psi. at 900 F. Its toughness is not diminished by lowering the temperature. Izod impact tests made at –300 F yield about the same values as at room temperature. At the low temperatures the tensile strength and yield strength are approximately 40% higher.

Monel has high resistance to corrosion against salt water, dilute sulfuric acid and strong caustic soda. It also resists cold hydrochloric acid, phosphoric acid, hydrofluoric acid, various organic acids and chlorinated hydrocarbons. However, it is not resistant to nitric acid, sulfurous acid and ferric chloride.

Monel is available in both cast and wrought form. The mill products are hot rolled and forged rods and bars, cold-drawn rods and bars, cold-drawn wire, hot rolled plates, cold-rolled sheet and strip in different tempers and finish, extruded and cold-drawn seamless tubing, hot-rolled angles, forgings and castings. It is used for all applications requiring strength and high resistance to corrosion as in building construction, vats, tanks, kettles, valves, pumps, shafts and propellers in marine industries, oil refining and chemical plant equipment, paper and pulp equipment and untold other products.

"R" Monel is a free-cutting grade of Monel obtained by adding about 0.035% sulfur to the alloy. It was developed primarily to improve the machinability of Monel for automatic screw machining. The additional sulfur does not impair or affect the strength or corrosion resistance of the alloy. It can be fabricated readily by cold forming operations, but is not generally recommended for hot forming operations. It is used for bolts, screws, precision parts and many other items requiring considerable machining.

"K" Monel and *"KR" Monel* are non-magnetic, age-hardening alloys of high strength and hardness comparable to the properties of heat treated alloy steel. They are highly corrosion resistant and non-magnetic. These alloys are of the Monel composition with about 2.75% aluminum. "KR" Monel is similar in composition to "K" Monel but with a higher carbon content to facilitate machining. The two alloys are available in wrought form only, especially as hot-rolled or forged rods, tubes, cold-drawn rods and wires and strip of various tempers. These alloys are suited for those applications requiring the high resistance to corrosion of Monel but higher mechanical properties, such as turbo-pump shafts, marine pump shafts, steam valve disks and seats, hydraulic valves, springs, wearing sleeves, liners, surgical blades and so forth. Their non-magnetic properties are the basis of applications for high strength parts of oil well survey equipment.

"H" Monel and *"S" Monel* are two cast alloys of the Monel type containing silicon for castability. "H" Monel with 3% silicon provides increased, but not maximum, hardness, with adequate ductility. It is used for parts requiring corrosion and erosion resistance where stresses are high as cast turbine nozzles. "S" Monel with 4% silicon can be age-hardened to 350 Brinell and has good resistance to galling and erosion. The material is particularly suitable for valve seats and plugs, sliding and other moving elements, bushings and disks for high temperature steam, pump liners and sleeves that must withstand severe abrasion and corrosion.

TABLE 2—NOMINAL CHEMICAL COMPOSITION

Material	Nickel * %	Copper %	Iron %	Manganese %	Silicon %	Chromium %	Molybdenum %	Carbon %	Other elements %
Nickel	99.4	0.1	0.15	0.2	0.05	—	—	0.10	—
L-Nickel	99.5	0.02	0.05	0.2	0.15	—	—	0.01	—
Z-Nickel	93.5	—	—	—	—	—	—	—	—
D-Nickel	95.2	0.05	0.15	4.5	0.05	—	—	0.10	—
E-Nickel	97.7	0.05	0.10	2.0	0.05	—	—	0.10	—
Monel	67.0	30.0	1.4	1.0	0.1	—	—	0.15	—
R-Monel	67.0	30.0	1.7	1.1	0.05	—	—	0.10	0.035 sulfur
K-Monel	66.0	29.0	0.9	0.85	1.0	—	—	0.15	2.75 aluminum
KR-Monel	66.0	29.0	0.9	0.85	1.0	—	—	0.30	2.75 aluminum
H-Monel	65.0	29.5	1.5	0.9	3.0	—	—	0.30	—
S-Monel	63.0	30.0	2.0	0.9	4.0	—	—	0.10	—
Inconel	78.5	0.2	6.5	0.25	0.25	14.0	—	0.08	—
60Ni-15Cr	62–	—	bal.	0.1–	1.0–	12–	—	0.06–	—
Type Alloy	54	—	—	1.0	1.5	20	—	1.0	—
Illium G	58.0	6.0	6.0	1.25	0.65	22.0	6.0	0.20	Tungsten
Hastelloy A	57.0	—	20.0	2.0	1.0	—	20.0	0.15	—
Hastelloy B	62.0	—	6.0	1.0	1.0	—	30.0	0.15	—
Hastelloy C	55.0	—	6.0	1.0	1.0	15.0	17.0	0.15	5.0 tungsten
Hastelloy D	85.0	3.0	—	1.0	10.0	—	—	—	1.0 aluminum

* The nickel values shown in the above table include a small amount of cobalt, approximately 0.75% of the nickel content.

Nickel-Silicon Alloy

Hastelloy D, manufactured by the Haynes-Stellite Co., is the best-known commercial alloy falling in the third group of nickel-base alloys. It contains about 10% silicon and small quantities of copper, aluminum and manganese. It is strong, tough and extremely hard. It has properties similar to a high grade of alloy cast iron and is not workable. Because of its high hardness, about 360 Brinell, it can be machined only with great difficulty, and must be finished by grinding. Its chief characteristic is its exceptional resistance to corrosion in hot or cold sulfuric acid, acetic acid, formic acid and phosphoric acid. However, it is not resistant to strong oxidizing acids. Hastelloy D is a cast alloy and is well suited for use in equipment where resistance to sulfuric acid and sulfuric anhydride is essential.

It can be used for kettles, evaporators, reaction vessels, mixers, pipe lines and fittings. This alloy is supplied as castings and as cast welding rod.

Nickel alloys with smaller percentages of silicon (less than 3%) are sometimes used in wire or filament form for electronic tube cathodes and as spark plug materials. The other grades of nickel-base alloys having small percentages of silicon are not included in the Nickel-Silicon group since the silicon is not present as the major alloying element.

Inconel is the material used in this exhaust manifold manufactured by the Kellett Autogiro Corp. (Courtesy: International Nickel Co.)

Nickel-Chromium-Iron Alloys

The fourth class of nickel-base alloys discussed here are those containing large percentages of chromium and iron as alloying elements. There are two types of alloys in this group, the 78 nickel; 14 chromium type as represented by Inconel of The International Nickel Co. and the 60 nickel; 15 chromium type as represented by a large number of cast and wrought alloys from different manufacturers. Inconel has the highest nickel content of all the alloys in this group, approximately 78.5% nickel, while the other alloys of the 60 nickel; 15 chromium type have a lower nickel range of 54 to 62%, but with larger percentages of chromium and iron.

The *60 nickel; 15 chromium Type* has good resistance to oxidation, heat fatigue and to carburizing gases. They are used widely in cast and wrought form for heat treating equipment, carburizing and nitriding containers, furnace parts, heating elements and other equipment that must withstand temperatures up to 1700 F and must be free from scaling and intercrystalline attack.

Inconel combines the inherent corrosion resistance, strength and toughness of nickel with the extra resistance to atmospheric and high temperature oxidation that is imparted by chromium. It resists the attack of such corrosives as caustic soda, hot fatty acids, dilute hydrochloric acid, nitric acid and other oxidizing liquids. The 60 nickel; 15 chromium type of alloys have almost similar corrosion resistance but not as effective. The unmatched ability of Inconel to withstand repeated heating and cooling in the range of 0 to 1600 F without becoming embrittled makes it the outstanding alloy for exhaust manifolds of airplane engines, for sheathing electric heating elements and for hot upset-head bolts that are used to reinforce the lining of fire boxes on ships. Its high corrosion resistance makes it suitable for the construction of brine-jacketed tanks and cooling equipment used for processing milk and milk products by the dairy industry, food processing equipment, heaters and condensers in the chemical industries, and equipment in allied industries.

In addition to high corrosion resistance, Inconel possesses a desirable combination of high strength and workability, both hot and cold. Tensile strengths reach as high as 185,000 psi. in heavily cold-worked wire. This alloy is excellent spring material especially at elevated temperatures, since it can be used up to 900 F without losing the spring properties. Inconel exhibits excellent resistance to this so-called relaxation of load loss when subjected to such high temperatures while under high stress. The springs are usually heated after forming for one hour at 900 F for best resistance to fatigue and to high temperature exposure.

This group of alloys is supplied by the mill in the form of hot-rolled and forged rods and bars, cold-drawn rods and bars, cold-drawn wire, hot rolled plates, cold-drawn sheet and strip, cold-drawn seamless tubing, and in castings. Gas welding wire and Flux welding electrodes of these materials are supplied for the welding of the alloys.

Inconel "X" is an age-hardenable Inconel and is one of the so-called "super-alloys." It was developed during the war for gas-turbine, supercharger, and jet-propulsion parts and is available now in forgings, bar stock, and wire. The alloy has good resistance to oxidation and high strength at elevated temperatures. Its stress-to-rupture strength, 1,000 hr., at 1500 F is in the range of 18,000 to 20,000 psi.

Nickel-Molybdenum-Iron Alloys

The fifth class of alloys are those containing large percentages of molybdenum and iron as alloying elements, and are comparable in strength and ductility to alloy steel. Two well known alloys, *Hastelloy A* and *Hastelloy B*, fall into this group and are characterized by their high resistance to corrosion in hydrochloric acid and wet hydrogen chloride gas; the B alloy is preferred for boiling acid. Their highest corrosion resistance, however, is developed when the material is in the soft condition obtained by quenching from 2100 to 2150 F. Being austenitic the alloys will not respond to age-hardening heat treatment, but can be cold-worked for increased hardness. Hastelloy B is richer in molybdenum and nickel than Hastelloy A, and consequently has better mechanical properties and superior corrosion resistance. Hastelloy A resists hydrochloric acid at moderate temperature and dilute sulfuric acid. Hastelloy B has better corrosion resistance to boiling hydrochloric acid and sulfuric acid.

These alloys are supplied in both the cast and wrought forms. They can be obtained as castings, forgings, hot rolled bars, plate, sheet, strip, rods, wire and welded tubing, or as welding rod. They find wide use in the chemical and allied industries for equipment to handle, transport and store acids and other corrosive materials. They are used for agitators, mixers, kettles, condensers, heat exchangers, dryers, evaporators and similar equipment.

Nickel-Chromium-Molybdenum-Iron Alloys

Hastelloy C and Illium G are in the sixth group of alloys, which are those containing large percentages of chromium, molybdenum and iron with nickel. They are especially characterized by their high corrosion resistance to oxidizing acids and mixtures, such as nitric, chromic and sulfuric acids, copper sulfate, etc. They are somewhat hard alloys and while difficult to either hot or cold work are available in several wrought forms as well as the more common castings. Their machinability can be improved by air cooling from the annealing temperature of 2150 to 2200 F. Welding can be done by either the oxy-acetylene or electric-arc method. The alloy Hastelloy C responds to age-hardening heat treatment for increased strength and hardness. Both alloys have high resistance to thermal shock.

These alloys are used in those industries requiring a strong alloy to resist corrosion in strong oxidizing acids and such oxidizing agents as free chlorine, bleaching agents and the like. They are used extensively for pump and valve parts, spray nozzles, piping and similar parts.

Hastelloy C can be obtained, in addition to castings, in plate, sheet, welded tubing and cast welding rod. Illium G can be obtained only in cast forms as castings, hardware, bar stock, centrifugally-cast pipe and welding rod.

Physical Characteristics

The more important physical constants of the wrought and cast materials are shown in Table 3 and Table 4. The specific gravity of each of these high nickel alloys is higher than that of steel and about the same as that of the copper alloys. The melting points are lower than steel but higher than copper alloys, while the electrical resistivity is much higher than copper, iron and steel. As reported by The International Nickel Co. the modulus of elasticity of their alloys are in general lower for the cast material than for the wrought material.

Mechanical Properties: Table 5 and Table 6 show the mechanical properties of the high nickel alloys in the cast and wrought condition. The values are the maximum and minimum properties that can be obtained in the different conditions of temper and treatment. For more detailed and specific properties the reader is referred to the manufacturer of the alloys and to their publications.

Hardness: Hardness is the most important factor, in addition to ductility and toughness, in effecting ease of fabrication and resistance to service wear and erosion. The high nickel alloys are all relatively hard and tough. Some can be softened by regular thermal treatments or by a high temperature quench. Others are hardened by cold working or by age-hardening heat treatment. These alloys, depending on their composition and also on their thermal and mechanical treatment, vary in hardness from 90 Brinell for annealed nickel to 550 Brinell (55 Rockwell C) for as-cast Hastelloy D.

Shear Strength: The high nickel alloys have shear strengths approximately 12 to 25% above those of steel for the equivalent hardness. The ratio of shear strength to tensile strength is 0.5 to 0.77 depending on composition and temper.

Compressive Strength: The yield strengths in compression are about equal to those in tension. Since the tests of the alloys showed that the material does not fracture it indicates that service overloads may cause only permanent set rather than sudden failures with subsequent damage to equipment. This is an important point in design.

Fatigue Strength: The endurance ratio, i.e., ratio of endurance limit to tensile strength, varies from 0.31 to 0.52 for the alloys depending on composition, temper, and thermal and mechanical treatments.

Impact Strength: The impact strength of the wrought materials is very high making them highly resistant to service shock and impact. The Izod impact values reach a high of 120 foot-lb. for hot-rolled or annealed nickel, Monel, "K" Monel and "Z" Nickel to a low of 25 foot-lb. for the same alloys in the heat-treated condition. Annealed Hastelloy A and B have impact values of 62 to 78 foot-lb. for the wrought material and 11 to 35 foot-lb. for the cast condition. It is to be expected that the impact values will be much lower for all the alloys in the as-cast condition than in the as-wrought condition.

Corrosion Fatigue: High nickel alloys have high resistance to corrosion fatigue, the combination of corrosive conditions and fatigue stresses acting together simultaneously. McAdam (2) showed in Table 7 how nickel and Monel compares with carbon steels in their resistance to corrosion-fatigue when exposed to fatigue stresses in air, in carbonate tap-water and in brackish estuarine water as follows:

Modulus of Elasticity: In construction of equipment, depending on its service and application, weight saving can be made by selecting material of high strength and high modulus of elasticity. This modulus property determines the rigidity and stiffness of the material. The higher the modulus the stiffer the material and the greater its resistance to sagging and deflection under load. Table 8 shows comparative moduli values of the high nickel alloys and other structural materials. This table can be used as a working guide in design and construction.

Magnetic Properties: Nickel is magnetic at temperatures below its transformation point, approximately 680 F. The magnetic induction is approximately 6100 Gausses at a field strength of 60 Gausses. Permeability or magnetic conductivity at low field strengths increases with temperature up to about 600 F. The high nickel-iron alloys, mentioned earlier, possess valuable magnetic properties. Certain of these alloys can, by special heat treatment, be made to emphasize one or more of the magnetic characteristics of this group. The high nickel-iron alloys of 70 to 85% nickel are characterized by high permeability at low field strengths and a low degree of magnetic retentivity or residual magnetism. The best magnetic properties are obtained after a high temperature annealing (about 2000 to 2100 F) in a hydrogen atmosphere followed by a very slow cool to room temperature at a rate not exceeding 200 F per hr. These alloys have been designated the Permalloys by the Bell Telephone Laboratories and Mumetal by the Allegheny-Ludlum Steel Co.

TABLE 3—PHYSICAL CONSTANTS OF WROUGHT MATERIAL

Material	Specific Gravity	Melting Point deg. F	Thermal Conductivity Btu/sq. ft./hr./deg. F/in.	Specific Heat Btu/lb./deg. F	Electrical Resistivity ohms/cir. mil foot	Modulus Elasticity 10^6 psi.
"A" Nickel	8.89	2615-2635	420	0.130	57	30
"L" Nickel	8.89	2615-2635	420	0.130	—	30
"Z" Nickel	8.75	2615-2635	420	0.130	260	30
"D" Nickel	8.78	2600	335	0.130	110	30
"E" Nickel	8.68	2600	335	0.130	85	30
Monel	8.84	2370-2460	180	0.130	290	26
"R" Monel	8.84	2370-2460	180	0.130	—	26
"K" Monel	8.47	2400-2460	130	0.130	350	26
"KR" Monel	8.47	2400-2460	130	—	—	26
Inconel	8.51	2540-2600	104	0.010	590	31
60Ni-15Cr	8.2-8.6	2450-2550	95-100	—	675	31
Hastelloy A	8.80	2370-2425	116	0.094	760	27
Hastelloy B	9.24	2410-2460	78.5	0.091	813	30.8
Hastelloy C	8.94	2320-2380	87	0.092	800	28.5

TABLE 4—PHYSICAL CONSTANTS OF CAST MATERIALS

Material	Specific Gravity	Melting Point deg. F	Thermal Conductivity Btu/sq. ft./hr./deg. F/in.	Specific Heat Btu/lb./deg. F	Electrical Resistivity ohms/cir. mil ft.	Modulus Elasticity 10^6 psi.
"A" Nickel	8.34	2540-2600	410	0.130	125	21.5
Monel	8.63	2400-2450	180	0.130	320	18.5
"H" Monel	8.48	2350-2400	180	0.130	370	20.0
"S" Monel	8.36	2300-2350	180	0.130	380	21.0
Inconel	8.3	2500-2550	—	0.110	—	22.7
60Ni-15Cr	8.3-8.5	2450-2550	25-100	—	675	30-31
Hastelloy A	8.8	2370-2425	116	0.094	760	27.0
Hastelloy B	9.24	2410-2460	78	0.091	813	30.8
Hastelloy C	8.94	2320-2380	87	0.092	800	28.5
Hastelloy D	7.8	2030-2050	145	0.109	680	28.9
Illium G	8.31	2375	—	0.105	735	—

The very low permeabilities of "K" Monel and of "KR" Monel are not affected by cold working or by age hardening, and the non-magnetic alloys can be used safely down to −150 F. The permeability of Inconel varies with cold work and thermal treatment. Cast Monel is weakly magnetic, while the two silicon Monels, "H" Monel and "S" Monel, are non-magnetic down to −70 F.

Electrical Properties: The electrical resistivity in ohms per circular mil foot for the high nickel alloys are shown in Tables 3 and 4. Some of these alloys are comparable to the special 80 nickel; 20 chromium type alloys which were developed for their high electrical resistance of about 650 ohms per cir. mil foot. However, the 80 nickel; 20 chromium type and the 60 nickel; 15 chromium type alloys are the only materials which will give optimum life as an electrical heating unit at high temperature. The maximum operating temperature for the 60 nickel; 15 chromium type alloys is about 1700 F as compared to 2100 F for the 80 nickel; 20 chromium type alloys. The Hastelloy and Illium alloys oxidize too rapidly at the service temperature to be useful for this purpose.

High Temperature Properties: Two essential characteristics that must be possessed by metals and alloys to be useful for heat resisting purposes are good resistance to oxidation (scaling) and high mechanical properties at the elevated temperatures. All the nickel-base alloys have high strength, high impact value and high resistance to oxidation, scaling, creep and intercrystalline attack at elevated temperatures. Their tensile and impact strengths are maintained at the high temperatures encountered in service. The higher the nickel content of the alloy the greater its resistance to oxidation and scaling. The nickel-chromium and the nickel-chromium-iron alloys are well established as heat resisting materials.

Because of its high melting point pure nickel is desired for industrial use at temperatures up to 2300 F under reducing and sulfur-free conditions where stress is negligible and resistance to scaling is of prime importance. Inconel under the same conditions is recommended for use up to 2100 F but can operate under high stresses. For parts or equipment involving oxidizing atmospheres, thermal shock and resistance to sudden or constant stress, Inconel is preferred over nickel. However, if sulfur-containing gases are present then Inconel can be used safely only up to 1500 F and nickel up to 1000 F in oxidizing atmospheres and to 1000 F and 500 F, respectively, in reducing atmospheres.

The advantage of these heat resisting alloys which maintain their strength at the elevated temperatures is that they do not deform under load.

TABLE 5—MECHANICAL PROPERTIES OF WROUGHT MATERIALS

Material	Yield Strength 0.2% Offset psi. 10^3	Tensile Strength psi. 10^3	Elongation in 2 in. %	Reduction Area %	Hardness Brinell	Charpy Impact ft.-lb.
"A" Nickel	15-155	60-165	50-2	75-50	90-230	222-195
"L" Nickel	15-25	55-75	55-35	75-50	25-55 (a)	—
"Z" Nickel	30-150	90-250	50-2	65-15	140-380	240-36 (b)
"D" Nickel	35-125	75-140	50-2	75-60	140-230	—
"E" Nickel	35-80	75-100	40-25	75-60	140-190	—
Monel	25-160	70-170	50-2	75-50	110-250	220-150
"R" Monel	25-130	70-140	50-4	70-50	110-230	196-140
"K" Monel	40-175	90-200	45-2	70-25	140-320	170-42 (b)
"KR" Monel	40-175	90-200	45-2	70-25	140-320	—
Inconel	25-175	80-185	50-2	70-40	120-290	77-62 (c)
60Ni-15Cr	40-160	80-175	35-0.5	70-40	180-235	78-68 (c) 40-34 (c)
Hastelloy A	47-52	110-120	48-40	54-40	200-215	—
Hastelloy B	60-65	130-140	45-40	45-40	210-235	—
Hastelloy C	55-65	115-128	50-25	—	160-210	—

(a) Rockwell B
(b) Specimens fractured completely
(c) Izod Impact

TABLE 6—MECHANICAL PROPERTIES OF CAST MATERIALS

Material	Yield Strength 0.2% Offset psi. 10^3	Tensile Strength psi. 10^3	Elongation in 2 in., %	Hardness Brinell	Izod Impact ft.-lb.
"A" Nickel	20-30	45-60	30-15	80-125	90-75
Monel	32.5-40	65-90	45-25	125-150	80-65
"H" Monel	45-75	90-115	20-10	175-250	45-35
"S" Monel	80-115	110-145	4-1	275-375	9-1
Inconel	30-45	70-95	30-10	160-190	85-70
60Ni-15Cr	40-60	60-70	5-2	170-210	—
Hastelloy A	43-45	69-78	12-8	155-200	35-25
Hastelloy B	55-57	75-82	9-6	190-230	16-11
Hastelloy C	45-48	72-80	10-15	175-215	14-9
Hastelloy D	36-41	36-41	0	50-55 (a)	—
Illium G	50-64	60-73	9-4	160-210	40 (b)

(a) Rockwell C
(b) Charpy

TABLE 7—ENDURANCE LIMIT AND APPARENT CORROSION-FATIGUE LIMIT

Material	Condition	Endurance Limits 10^8 Cycles psi.	Apparent Corrosion-Fatigue Limit 10^8 Cycles psi.	
			Fresh Water	Brackish Water
Nickel	Annealed	33000	21-24000	20-22000
	Cold-worked	50000	21-24000	20-22000
Monel	Annealed	36000	21-24000	27-29000
	Cold-worked	50000	21-24000	27-29000
Carbon Steels	—	25-42000	16-24000	6-8000

TABLE 8—MODULUS OF ELASTICITY

Material	Tension or Compression Young's Modulus psi.	Shear or Torsion Rigidity Modulus psi.
Monel	26,000,000	9,500,000
"K" Monel	26,000,000	9,500,000
"A" Nickel	30,000,000	11,000,000
"Z" Nickel	30,000,000	11,000,000
"E" Nickel	30,000,000	11,000,000
Inconel	31,000,000	11,000,000
Brass	14,500,000	5,000,000
Silicon Bronze	15,000,000	5,000,000
Carbon Steel	30,000,000	11,500,000
14Cr-Steel	28,000,000	10,000,000
18:8 Steel	28,000,000	10,500,000
Hastelloy A	27,000,000	
Hastelloy B	30,750,000	
Hastelloy C	28,500,000	
Hastelloy D	28,880,000	

Low Temperature Properties: At sub-zero temperatures the nickel-base alloys have increased strength and hardness, and at the same time retain their toughness. This is marked contrast to other engineering materials which become brittle and have low ductility at low temperatures.

A summary of the low temperature properties of Nickel, Monel, "K" Monel and Inconel which shows that the strength factors increase as the temperature is lowered is given in Table 9. Freedom from low temperature brittleness is indicated by the high impact strength at the subzero-temperatures. This establishes the virtue of the nickel-base alloys for industrial use at very low temperatures, namely, that there is no appreciable loss in impact strength even though the tensile strength increases considerably. It is also found that the fatigue strength and modulus of elasticity likewise increase at lower temperatures. In general the ductility, as measured by the per cent elongation and contraction, also increases to some extent as the temperature drops.

TABLE 9—MECHANICAL PROPERTIES AT LOW TEMPERATURES

Material	Conditions	Temp. deg. F	Yield strength 0.2% Offset psi.	Tensile Strength psi.	Elongation in 2 in. %	Reduction of Area %	Charpy Impact Strength ft.-lb.
Monel	Forged	70	67,000	92,000	31.0	72.7	216
		−297	91,500	128,250	44.5	71.8	216
		−423	96,400	142,000	38.5	61.0	—
	Annealed	70	31,300	78,650	51.5	75.0	216
		−297	49,500	115,250	49.5	73.9	212
Nickel	Hot-rolled	70	24,600	65,600	—	—	195
		−112	27,500	76,400	—	—	236
		−292	28,000	98,000	—	—	—
		−310	—	103,000	51.0	—	227
Inconel	Hot-rolled	70	—	87,000	42.5	71.9	213
		−315	—	116,750	51.0	72.7	169
	Cold-drawn, 50% reduction	70	—	145,000	10.0	35.1	69
		−315	—	182,000	10.0	49.5	61
"K" Monel	Cold-drawn, age-harden	70	125,900	157,300	15.5	37.4	—
		−110	134,600	171,550	17.3	41.1	—

Hot Forming of Nickel-Base Alloys

Hot Working: Hot working and hot forming of high nickel alloys necessitates more careful control of atmospheres and temperatures than for steel and other nonferrous alloys. The susceptibility of nickel and nickel alloys to intergranular attack by sulfur at high temperatures calls for the working of the material in a sulfur-free atmosphere or at least in atmosphere produced from fuel containing not more than 0.5% sulfur. Coal and coke as furnace fuels are not recommended as they produce atmospheres too high in sulfur. Satisfactory fuels are natural gas, butane, propane, and low sulfur city gas or fuel oil. Excessive long periods at the high heat are undesirable and soaking at the high heat must be avoided. The material should be heated just sufficiently long to ensure uniformity of temperature throughout the mass or throughout each piece. However, long periods of heating are not particularly detrimental for the Hastelloy alloys.

Nickel-base alloys do not scale readily and also do not carburize. Thus a slight excess of reducing atmosphere, about 2% carbon monoxide, will prevent oxidation. Furnace atmospheres must never be allowed to alternate from reducing to oxidizing as severe intergranular attack with resultant embrittlement will occur.

After hot forming the materials may be cooled in air except the age-hardenable alloys which must be quenched in water to prevent hardening during slow cooling.

Hot Forging: Since nickel-base alloys are stronger and tougher than steel at forging temperatures, usually heavier forging hammers and larger presses are required, especially for single blow operations as in pressing and in heading bolts. However, forging of these alloys can be readily produced by the hammer forge, drop forge or press forge methods, if correct heating methods are followed. The Hastelloy alloys are somewhat stiffer at high temperatures than the Inco high nickel alloys, and therefore do not forge as readily. But with hydraulic forging presses best results are obtained. The heating atmosphere in contact with the metal should be reducing to about 2 to 5% excess carbon monoxide.

The high nickel alloys show important differences among themselves as to proper forging temperatures, particularly in the upper safe heating limits, and in tendencies towards red-shortness. Too high temperatures are damaging to the alloys. Nickel must not be heated above 2300 F. It is not practical to forge Hastelloy C. Of course it is understood that the cast alloys such as Hastelloy D, "H" Monel and "S" Monel cannot be forged.

The hot forging temperatures are the same as the hot forming temperatures as shown in Table 10. The Hastelloy alloys must be forged at temperatures above 1900 F, preferably around 2100 F because of the great danger of cracking in the brittle range below 1900 F. These alloys possess a brittle range between 1200 and 1900 F and cracking may occur in this range unless the flow of the metal is extremely slow. If heat treatment is to follow the hot forging operation of the age-hardenable alloys then it is necessary to reheat and quench to avoid self-hardening on slow cooling and setting up of stresses that may result in cracks or surface tears. "Z" Nickel should be quenched from 1900 to 2000 F, while "K" Monel should be quenched from above 1450 F.

The metal in the forging furnace should be supported on steel rails and should not be allowed to touch the furnace floor owing to possible contamination with sulfur from the hearth slag. Billets should not be kept exposed to combustion gases in a heating furnace longer than the minimum time required to heat the piece uniformly through.

The use of regular hot-rolled rods for forging is satisfactory provided that they are overhauled at the mill. The overhauling of stock 1-in. and over consists of deskinning on a special continuous turning machine. Rods under 1-in. dia. are centerless ground. Overhauling of sections other than rounds can be done only by hand grinding.

Hot Working Temperatures

The recommended hot-working, hot-forming and hot-forging temperatures are as follows:

TABLE 10—HOT WORKING TEMPERATURES

Material	Temperature, F
"A" Nickel	2300 - 1600
"L" Nickel	2300 - 1600
"Z" Nickel	2150 - 1850
"D" Nickel	2150 - 1600
"E" Nickel	2150 - 1600
Monel	2150 - 1600
"K" Monel	2150 - 1900
"KR" Monel	2150 - 1900
Inconel	2300 - 1850
60Ni-15Cr Type	2250 - 1850
Hastelloy A	2200 - 1950
Hastelloy B	2200 - 1950
Hastelloy C	2250 - 2000

Precautions: Nickel stiffens rapidly at about 1600 F. Do not heat above 2300 F. Forge lightly between 1000 to 1200 F for high physical properties. Hot bend between 2250 to 1900 F.

"Z" nickel stiffens rapidly below 1800 F.

"D" nickel and Monel must not be heated above 2150 F. Heavy forging should be done above 1850 F and the hot bending should be done between 2150 and 1850 F.

"K" Monel and "KR" Monel should never be charged in a cold furnace, but always in a hot furnace. The parts should be quenched from forging or hot-working heat and should not be allowed to air cool.

Hastelloy A, B and C harden and become brittle between 1200 and 1900 F, and this temperature range should definitely be avoided.

Die Steels: Nickel-chromium-molybdenum steel of about 0.50 to 0.55% carbon, heat treated to 42 to 44 Rockwell C, makes the best forging dies. The tendency for the hot metal to stick to the die can be prevented by swabbing the die faces with a mixture of heavy grease and graphite, or by throwing sawdust into the die.

Heat Treating

Annealing: Nickel and the nickel-base alloys are subject to annealing heat treatments to accomplish softening after cold working, to relieve stresses induced by cold working, welding or machining, to improve machinability, and to restore corrosion resistance. Similar precautions must be considered and must be taken during heating and cooling on annealing as on hot-working.

Soft Anneal: The purpose of a soft anneal is to decrease hardness and increase ductility of partially cold-worked material in order to complete fabrication by cold work without rupture. As with other alloys the greater the amount of cold work to which the materials have been subjected the lower is the annealing temperature required to produce the same degree of softness without increased grain size, or the shorter is the time required at temperature. Soft annealing requires a sulfur-free atmosphere and accurate control of time and temperature to avoid intergranular embrittlement by the sulfur and abnormal grain growth by too high a temperature. The temperatures required are sufficiently high to cause surface oxidation. Heating in atmospheres that fluctuate from oxidizing (excess air) to reducing (excess carbon monoxide and hydrogen) causes severe intercrystalline attack, with resulting embrittlement, even though the atmosphere is sulfur-free. By maintaining a slight excess of reducing gas in the atmosphere during heating and cooling this trouble can be avoided. Since the rate of cooling after anneal has no specific effect on the resulting softness of the material, it is advisable to quench from the annealing temperatures to minimize oxidation. However furnace cooling is essential for Hastelloy D. The age-hardening alloys must be cooled rapidly to prevent self-hardening.

Material can be either box annealed or open annealed. Open annealed material should be quenched in a solution of 2 to 3% denatured alcohol in water to reduce the oxide flash when the work is brought out into the air, and thus obtaining a silvery white surface on the part.

The recommended soft annealing temperatures for open annealing are as follows:

1500 to 1700 F for "A" Nickel, "L" Nickel, "K" Monel, and "KR" Monel
1600 to 1800 F for "D" Nickel, "E" Nickel, and Monel
1600 to 2000 F for "Z" Nickel and 60Ni-15Cr Type
1800 to 1950 F for Inconel
2100 to 2150 F for Hastelloy A and Hastelloy B
2200 to 2250 F for Hastelloy C

Box annealing can be done at about 250 F lower temperature than open annealing but requires more time. Box annealing is not generally used except for small parts requiring special handling. Special work with small parts can be soft annealed in salt baths of molten chlorides and carbonates of sodium and potassium. The addition of powdered borax or charcoal to the fused salt bath removes all traces of sulfur which might embrittle the work. The annealed material is quenched in water to remove the adhering salts and then flash pickled.

Temper Anneal: Temper or partial anneal is limited to light sections and is applied to strip and wire where full annealed material is not required or where partial softening is desired. The temper is lower than that for soft anneal but higher than that for stress equalizing or stress relief anneal. Lower temperatures and shorter times are recommended for temper anneal.

Stabilizing Anneal: The Hastelloy alloys are usually used in the fully-annealed condition. They are given a stabilizing anneal at 1925 to 1950 F from 2 to 4 hr. to reduce loss of corrosion resistance and toughness due to exposure in the temperature range of 1200 to 1900 F. Hard, brittle Hastelloy D is toughened by heating at 1925 to 1950 F for 2 to 4 hr. and furnace cooling. For Hastelloy C it is recommended to air cool from 2050 to 2075 F.

Stress-Equalizing Anneal: This stress-equalizing or partial stress-relief anneal requires a low temperature thermal treatment of cold-worked or hot-worked material to develop the optimum combination of strength and ductility, and to insure against distortion and warping during subsequent machining. This treatment does not relieve nor remove the stresses and does not alter the grain structure, but does increase the proportional and elastic limits. Hot-worked material requires a higher temperature than cold-worked material for this type of anneal. The recommended stress equalizing temperatures for cold-worked materials are: 525 to 750 F for Monel, "R" Monel and nickel; 800 to 900 F for Inconel; 950 to 1000 F for the 60 nickel; 15 chromium Type alloys; and 1100 F for the Hastelloy alloys. High tensile forgings of nickel, Monel and Inconel are treated at 1000 F. Cold-worked and unage-hardened "K" Monel, "KR" Monel and "Z" nickel are treated at 525 to 750 F.

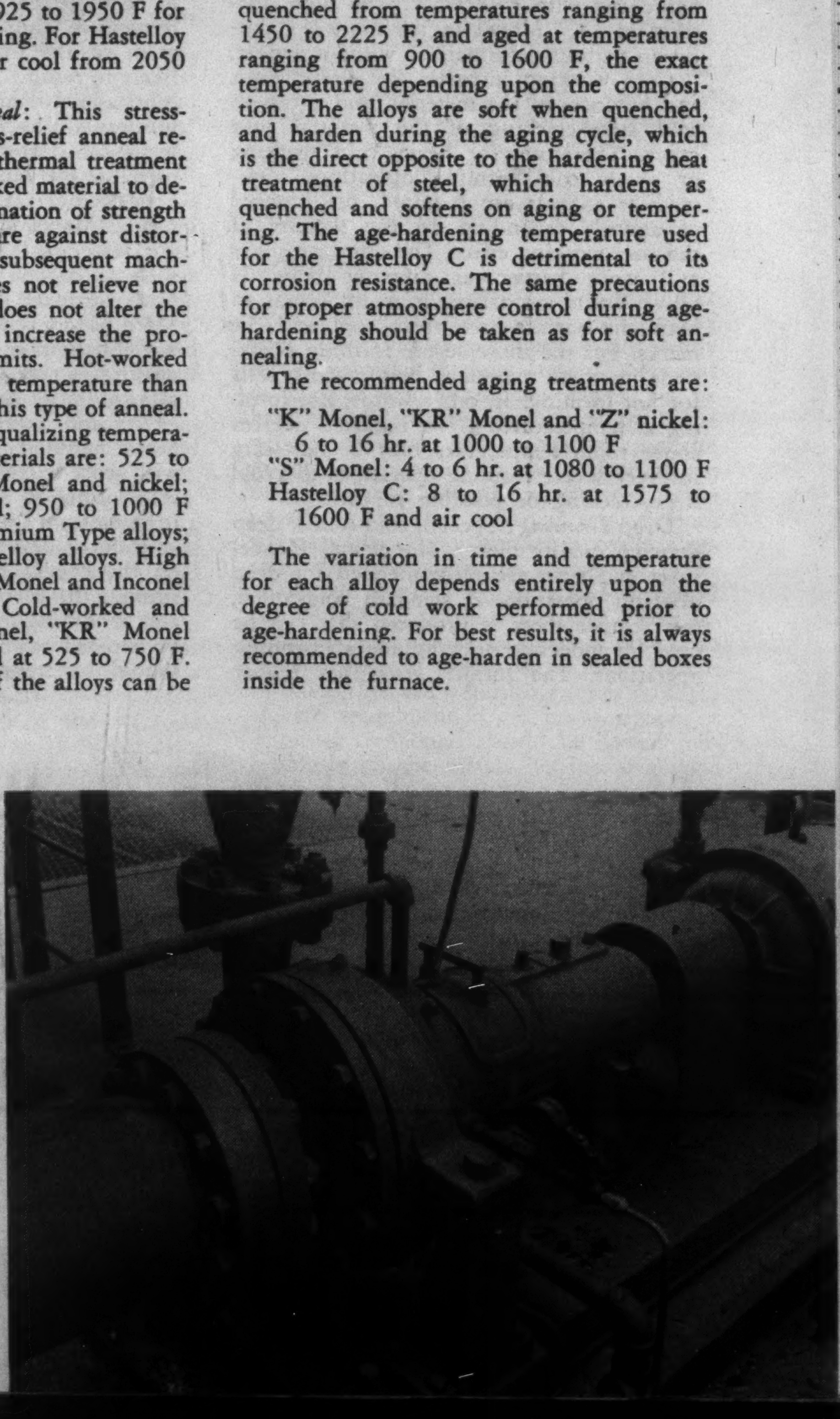
Bright Anneal: Most of the alloys can be bright annealed in reducing atmospheres containing small amounts of steam and carbon dioxide. However, "K" Monel, "Z" nickel, and the chromium-containing alloys require a pure hydrogen or hydrogen-nitrogen atmosphere. Bright annealing is easier by open-annealing methods than by closed box or pot methods. Suitable atmospheres for bright annealing include hydrogen, cracked ammonia, nitrogen, cracked and sulfur-free natural or city gas, cracked hydrocarbons, or generated atmosphere containing principally a mixture of carbon monoxide and hydrogen. Hydrogen is preferred for the Hastelloy alloys.

Age-Hardening: Only five of the high nickel alloys can be age-hardened by suitable heat treatment. They are "Z" nickel, "K" Monel, "KR" Monel, "S" Monel, and Hastelloy C. The other alloys do not respond to age-hardening thermal treatment and can be hardened only by cold work. In this age-hardening heat treatment the alloys are quenched from temperatures ranging from 1450 to 2225 F, and aged at temperatures ranging from 900 to 1600 F, the exact temperature depending upon the composition. The alloys are soft when quenched, and harden during the aging cycle, which is the direct opposite to the hardening heat treatment of steel, which hardens as quenched and softens on aging or tempering. The age-hardening temperature used for the Hastelloy C is detrimental to its corrosion resistance. The same precautions for proper atmosphere control during age-hardening should be taken as for soft annealing.

The recommended aging treatments are:

"K" Monel, "KR" Monel and "Z" nickel: 6 to 16 hr. at 1000 to 1100 F
"S" Monel: 4 to 6 hr. at 1080 to 1100 F
Hastelloy C: 8 to 16 hr. at 1575 to 1600 F and air cool

The variation in time and temperature for each alloy depends entirely upon the degree of cold work performed prior to age-hardening. For best results, it is always recommended to age-harden in sealed boxes inside the furnace.



Cast Hastelloy B is used throughout this centrifugal pump for moving aromatic hydrocarbons. (Courtesy: Haynes Stellite Co.)

Cold Forming

Most of the high nickel alloys can be cold worked. The cast alloys as "H" Monel, "S" Monel, Hastelloy D and Illium G are too brittle and too hard for any cold forming operation. Hastelloy A, B and C can be cold-worked, but it is not very practical and they are, therefore, not supplied in the cold-rolled or cold-drawn condition. Those alloys that can be cold-worked satisfactorily are available as cold-rolled sheet and strip, cold-drawn bars and rods, and cold-drawn seamless tubing and wire.

Nickel, Monel and Inconel behave similarly in many respects to mild steel in mechanical cold working operations, such as cupping, drawing, swaging, die forming and bending. However, because of their higher elastic limit, more power is required. Inconel is tougher to cold work than either nickel or Monel. "L" nickel is softer than regular nickel and does not work harden as rapidly. The ductility of "Z" nickel permits excessive cold working without danger of fracture despite the fact that it work hardens more rapidly than regular nickel. However, more frequent annealing is required for "Z" nickel during heavy cold working. "K" Monel is harder than Monel and also has a greater rate of hardening with cold work. The high ductility of "K" Monel in the annealed condition permits deformations without danger.

Cold working increases the elastic limit and hardness of the material, and excessive cold stress-cracking of the material may occur. Therefore, for heavy cold working or severe cold forming operations intermediate anneals are required, the number of anneals depending on the severity of the cold working effect. The different alloys will work harden at different rates. If heavy drafts are taken, it is important to keep the surface free from tool and die marks. For the more severe forming operations on these materials, best practice calls for hot forming. In other words, hot forming at temperatures a few hundred degrees above room temperature may be necessary for very severe forming operations to avoid stress-cracking or possible rupture.

Deep Drawing: Special, cold-rolled, deep drawing quality nickel, Monel and Inconel sheet and strip are recommended for deep drawing operation. A standard cold-rolled, soft temper sheet is produced that can be used for moderate drawing and all bending operations. The former grade has higher ductility than the latter, and is available in a range of tempers from dead soft to full hard. Soft temper stock with fine to medium grain is the most suitable for deep drawing. Dead soft material has the highest ductility but will have a coarse grained structure which will cause a pebbled surface on the finish drawn part.

The Hastelloy A, B and C alloys work harden in deep drawing, but not sufficiently to necessitate subsequent heat treatment for maximum corrosion resistance. Severe deep drawing must be performed hot within the temperature range of 1900 to 2200 F. The brittle range of 1200 to 1900 F for these alloys must be avoided. After all forming operations, either hot or cold, the parts should be given a full anneal or stabilizing anneal for maximum corrosion resistance.

For die materials, heat treated nickel-chromium cast iron, hard alloy bronze, chromium plated hardened alloy die steel or carbides can be used. Sulfur-free lubricants having high film strength are preferred for drawing nickel and the high nickel alloys; beef tallow, castor oil, or a mixture of the two, is recommended.

Lubricants should be thoroughly removed from drawn articles, especially those to be subjected to high temperatures or intermediate annealing; otherwise embrittlement of the material by the lubricant is likely to result. Water-soluble or oil-soluble lubricants containing fillers are also good lubricants. In general, the same die equipment for drawing steel and brass can be used for the high nickel alloys.

Spinning: In the annealed condition, nickel, Monel and Inconel sheet and strip are less ductile than the softer materials, such as copper, brass and aluminum, but have adequate ductility for the operation. More power is required when spinning the nickel-base alloys, and more frequent annealing is necessary because of the greater rate of work-hardening. Work-hardening effects the power required for spinning. Since hardness and elastic limit increase with work-hardening, the more the material is deformed in spinning, the more difficult it becomes to continue the spinning without annealing. The work should be laid down on the chucks firmly with long powerful strokes, the metal should not be crowded, and reworking over the same surface should be avoided as much as possible. Spinning should be stopped as soon as the metal ceases to flow. If the spinning is carried too far, numerous small surface cracks will be developed, indicating overstrained material which cannot be restored by either annealing or burnishing.

Hard alloy bronze, highly polished, is recommended for bar tools, and hardened chromium plated tool steels are preferred for roller and beading tools. Spinning tools should be made broad and flat to distribute plastic flow over a greater area and to reduce over-straining.

The lubricant used is an important factor in the successful spinning of these materials. It should be heavy-bodied to withstand the high pressures and temperatures developed. Yellow laundry soap is used most frequently, but beeswax, tallow or a mixture of the two, are also satisfactory. Removal of lubricants from spun articles is just as essential as their removal from drawn articles. Dead soft annealed material is undesirable for spinning, owing to the coarse grain.

Special spinning stock is available from the mill and should be specified. "L" nickel, the carbon-free grade, spins almost as easily as copper.

Shearing: Shearing of nickel, Monel and Inconel sheet and strip require from about 115% in the soft tempers to about 130% in the full hard tempers, the power needed for mild steel of equal gage. The Hastelloy alloys require still higher power, closer to 150%, and can be sheared hot or cold. Shear blades must be set up tightly and kept sharp.

Punching: Punching and perforating require about 15 to 20% more shear load for high nickel alloys than for mild steel of equal gage. The material should be soft to skin-hard temper. Usually a total punch and die clearance of 3 to 6% of the thickness of the stock punched is satisfactory for punching and perforating nickel, Monel and Inconel. It is advisable to have close clearance between the punch and the stripper plate. A heavy sulfur-base oil is recommended as lubricant. The same precaution regarding the removal of lubricants should be observed as that described previously for deep drawing and spinning.

Soft, skin-hard and quarter-hard temper material is recommended for perforating. A cleaner cut is obtained with quarter-hard temper material, and the choice between the three tempers will depend upon the job at hand.

Machining

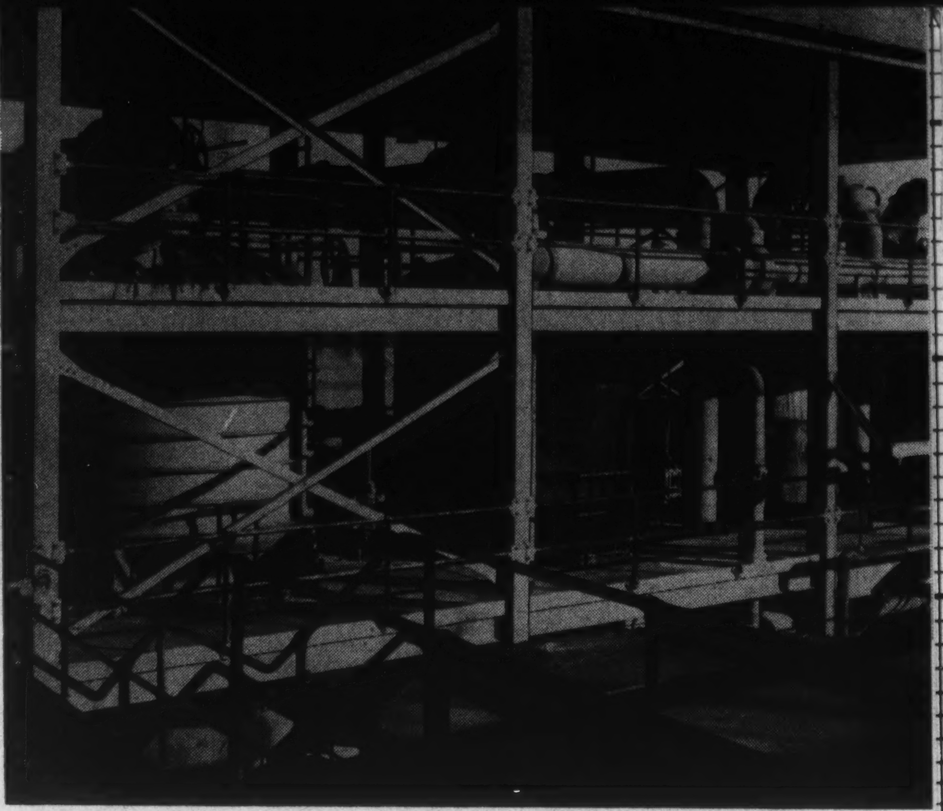
The combination of high strength, high ductility and toughness of the nickel-base alloys decreases their machinability rating below that of machinery steels and calls for machining procedures somewhat different from those employed for materials of lower strength, toughness, hardness and ductility. The alloys are not difficult to machine when the proper tooling, feed and speed and also cutting compound are used. Furthermore, two of the alloys, "R" Monel and "KR" Monel, have been developed for free-cutting and automatic screw machining.

The best grades of wrought nickel and Monel for easy machining are those in the "as-cold-drawn and normalized" temper, while the desired condition for Inconel and "K" Monel are annealed, hot-rolled or cold-drawn bars and rods. Nickel and the high nickel castings are nearly always machined in the as-cast condition. "S" Monel, which responds to hardening by thermal treatment, has the highest order of machinability in the annealed condition. Unless difficult and extreme machining is involved, the as-cast material is satisfactory. The Hastelloy alloys and Illium G must be machined in the soft-annealed condition.

Cutting Procedure

Slower cutting speeds and lighter cuts than for machinery steels are generally recommended. In turning and boring it is desirable, and decidedly more economical, from a tool life point of view, whether cutting dry or with a lubricant, to take a deep cut and light feed rather than a light cut and heavy feed. Cutting edges must be kept sharp and tools must be cutting when against the work. If allowed to ride on the work without cutting, it will be difficult for the tool to pick up and cut again. Tools must be properly supported, for otherwise chattering will develop. Sufficient true rake on the tool face must be ground to keep chip pressure, chip abrasion, and resultant frictional heat at a minimum and to provide for convenient chip disposal.

Proper chip disposal is an important factor in heavy roughing operations and chip breakers aid materially. A heavy, continuous spiral chip cannot be properly disposed of on heavy rough cuts with tools not utilizing a chip breaker. Chip control is assisted by reducing the normal side rake to a degree where the heavy chip will pack against the tool face, become embrittled, and break when it curls back against the work.



Solid nickel tubes are used in this battery of four nickel-clad steel evaporators. Each evaporator has 4,000 sq. ft. of nickel surface. The evaporators handle a caustic solution varying from 12 to 70% concentration. (Courtesy: Lukens Steel Co.)

Cutting Tools

In practice, recommendations are to use cutting tools ground with sharp cutting edges having minimum relief, to avoid excessive speeds and feeds, and to keep the work well flooded with lubricant. Carbon tool steels cannot be used with the high nickel materials, owing to the high frictional heat developed which will draw the temper of the cutting edge. High speed and super high-speed steels are recommended. The higher hot hardness of the latter type will afford longer tool life between grinds. The cast nonferrous and cemented carbide tools follow in order with regard to higher hot hardness and increased cutting speeds. For machining the hard cast alloys, it is advisable to use the tungsten or tantalum carbide tipped tools or the nonferrous cutting tools, such as Rexalloy, Stellite "2400," Star "J" Metal or Tantung "G." The selection of the cutting tool will depend on the alloy and the condition of the alloy being machined, and also on the machine tool set-up.

For intermittent cutting and heavy roughing, the high-speed steel should be heat treated to 58 to 61 Rockwell C. For light smooth lathe turning and for automatic machining, tools above 61 Rockwell C hardness are preferred. The ground rakes and angles on the cutting tool will vary, depending on the material being cut and on the particular machining operation. However, they should be ground with sharp edges, greater rakes to reduce chip pressure and blunt noses to provide maximum support for the cutting edge.

Tool Angles and Rakes

For turning the wrought alloys, front and side relief angles should be about 6 to 8 deg. on roughing tools and from 12 to 15 deg. on finishing tools. Depending on the alloy and type of cut, side rake angles will vary from about 10 deg. for heavy, dry, rough cutting, to as high as 25 deg. on smaller lathe turning and finishing tools where the amount of metal removed is small. A nose radius of 1/8-in. is advisable for rough cuts and 1/16-in. for finish cuts. For rough cutting castings, the cutting edge of the tool should be more blunt and have an almost perpendicular land of about 1/32-in. width to reduce the end relief. For rough tuning Illium G castings, a high-speed steel having a front relief of 5 deg., a side relief of 4 deg., a zero back rake and a 5-deg. side rake has been found to work well; and for finishing, the same tool with a 3-deg. back rake works well.

Speed, Feed, Depth of Cut

Wrought nickel and Monel can be turned on a lathe at 40 to 65 ft. per min., wrought Inconel and unhardened "K" Monel at 30 to 45 ft. per min., cast nickel at 40 to 60 ft. per min., and cast Monel at 40 to 50 ft. per min. when cutting dry with high-speed steel, using a 1/8-in. depth of cut and a feed of 1/64-in. per revolution. Under the same conditions, cast "H" Monel and annealed cast "S" Monel can be turned at 25 to 35 ft. per min. With the use of proper cutting fluid, all of the above turning speeds can be increased about 20 to 25%. The most satisfactory cutting speed for Illium G castings is from 20 to 25 ft. per min., with a feed of about 0.032 in, For automatic machining of the free-cutting grade "R" Monel, the recommended speeds are 100 to 125 ft. per min. under normal conditions. Unhardened "KR" Monel is machined at a lower speed of 60 to 80 ft. per min. Too low speeds should not be used when automatic screw machining as the material work-hardens.

For planing and shaping the wrought alloys, table speeds of 25 to 35 ft. per min. for nickel and Monel, and 15 to 20 ft. per min. for Inconel and unhardened "K" Monel have proved satisfactory. When roughing, depth of cut should range from 1/16 to 3/8 in. with feeds of 3/32 to 3/64 in., respectively; while a 0.020-in. depth of cut with a feed of 11/32 in., or of 0.010 in. with 3/8-in. feed, works well for finishing.

Cutting and Grinding Fluids

Sulfurized oil is recommended for machining nickel and the high nickel alloys with HSS tools; and a rich emulsion for cemented carbide tools. A rich emulsion of water-soluble oil is sometimes preferred for planing and shaping because of its tendency to smoke less. Turpentine or gasoline is recommended for drilling under 3/32 in.; while lard oil, water-soluble oil or sulfurized oil, depending on the alloy, are used for drilling for 1/4 in.

Grinding is done with a lubricant of soda and water or a lean mixture of soluble oil and water. The manufacturers of the Hastelloy alloys do not recommend the use of sulfurized oils for their alloys, but instead water-soluble oil, lard oil or mineral-lard oil. Discoloration produced by sulfurized oil can be removed readily by soaking the work from 20 to 30 min. in a cold 10% sodium cyanide solution.

Grinding

Methods of grinding nickel do not differ from the practices followed in grinding steel. Grinding wheels must be sufficiently soft to permit a moderate rate of wear and to prevent loading of the wheel, yet be hard enough to prevent undue wear. If the wheels are too hard, abrasive particles might be embedded in the surface of the material being ground which may cause scratching of a mating part in service. Both silicon carbide and aluminum oxide abrasive wheels are used, the former for cylindrical and internal grinding and the latter for surface grinding operations. For reciprocating grinding of Inconel, a silicon carbide wheel is preferred. A roughing cut of 0.0005 in. and a finishing cut of 0.00025 in. are recommended. A heavy stream of grinding compound should be flowed continuously on the metal. To insure a good finish, keep the wheel from loading, reduce frequent wheel dressing, and allow grinding to close limits.

When the finishing operation is to be grinding and the stock to be removed is not too great, all work can be done on a grinding machine using a roughing and finishing operation. If extremely accurate ground finish is desired, the finish-machined or rough-ground parts should be allowed to age at room temperature for several days or a few hours at 525 F to remove internal stresses introduced during the machine operations. Any distortion taking place during aging will be removed on finish grinding and thereby stable and accurate dimensions will result. Material to be surface ground should be stress equalized annealed at 525 F for optimum flatness.

Care must be taken to prevent overheating by too heavy grinding pressures. Excessive heat will destroy the true color of the buffed metal and may warp flat, light gage material.

For polishing ground surfaces use spirally machine-sewed wheels of tightly woven unbleached cotton fabric.

For buffing use sturdy, closely woven, high count sheeting wheels. Close weaves give good cutting and heavy threads give good coloring. Buffing depends on the multiplicity of thread and stiffness for its cutting action.

Joining Practices

The regular joining practices and processes of soldering, brazing and welding employed for steel can be used for the high nickel alloys with slight modifications. The method of joining and the filler used will depend on the design, service stresses and service exposure to elevated temperatures and corroding media. Each method produces satisfactory joints and has its own field of application.

Soldering is satisfactorily performed with the 50-50 and 60-40 tin-lead soft solders using "cut acid" fluxes. Soldered joints can be used only in those applications where the joint does not come into contact with corroding agents, high temperatures and high stresses. Due to the chromium oxide film on Inconel and the 60 nickel-15 chromium type alloys, stronger fluxes are required when soldering these alloys than when soldering nickel or the Monels. In all cases the oxide film should be removed by grinding, polishing or pickling before soldering. Pretinning the surfaces before soldering and after cleaning is highly recommended. This can be done with the same solder as that to be used for the joint. Soft soldering can be done with a soldering iron, with oxy-acetylene flame or with air-acetylene flame.

Brazing requires silver brazing alloys which flow at less than 1400 F, preferably those that melt or flow in the temperature range of 1160 to 1325 F. Two well recommended alloys are Handy and Harman's "Easy-Flo" (50Ag;15.5Cu;16.5Zn;18Cd) which melts at 1160 F and flows at 1175 F, and their Grade RT (60Ag;25Cu;15Zn) which melts at 1260 F and flows at 1325 F. "Handy Flux" is used with both of these brazing alloys. Other proprietary silver brazing alloys with the proper melting and flow temperatures can be used. Borax and boric acid fluxes cannot be used because they are not fluid at the brazing temperatures used. Phosphorus-containing alloys, although excellent brazing material for copper and brass, are not recommended for high nickel alloys because of the high embrittling effect of the phosphorus.

Brazing operations are avoided generally with the Hastelloy alloys because of the severity of the corrosion problems involved.

The strength of a properly designed joint should be approximately 50,000 psi. in tension and 30,000 psi. in shear. Recommended clearances of 0.002- to 0.003-in. should be used to allow proper drawing of the molten brazing alloy through the joint by capillary attraction. Excessive clearances result in low strength.

Brazing can be done by heating with a neutral or slightly reducing oxy-acetylene flame, by heating the assembly in an electric furnace, by induction heating, or by dipping in a bath of molten salt. Since brazing is performed well below the annealing temperatures of the high nickel alloys, there is little softening effect. The age-hardenable alloys can be heat treated before or after brazing.

Furnace brazing, and copper and brass brazing of high nickel alloys are used for special purposes only.

Oxy-Acetylene Welding

In oxy-acetylene welding a slightly reducing, i.e., carburizing flame with just a little excess of acetylene is recommended. A slight feather, no longer than 1/16-in. showing beyond the tip of the luminous cone should be maintained. During welding the end of the welding rod always should be kept well within the protecting flame envelope to prevent oxidation of the hot welding rod. Surface preparation of the material to be welded should be done as for steel welding. Surface freedom from oxide film, grease and dirt, are very important for good strong joints. A flux is required for Monel and Inconel, but none is required for gas welding nickel. When fluxes are used they need not be removed after the completion of the welding as the recommended fluxes do not corrode the high nickel alloys. In general, the welding rods are uncoated (bare) and are of the same material as the alloy to be welded.

Good welding is accomplished in flat, vertical and overhead positions. Where high stresses are not encountered corner welds and lap joints can be used. Where high stresses are encountered butt joints are preferred. It has been recommended to bevel the plate edges to a 37.5-deg. angle on each side to form V-joints for material over 5/32-in. thick. Thinner plate and sheets need not be beveled. Some of the high nickel alloys such as Monel flow freely from the filler rod to the joint, while others are a little sluggish. For best results, puddling should be avoided, the molten pools of metal should be kept quiet and the tip of the luminous flame should just touch its surface.

Gas welds of "K" Monel have a cast structure and will respond to the same heat treatment (age-hardening) as the wrought material. "Z" nickel is welded with regular nickel welding rod and the joints therefore cannot be age-hardened, but the joints are nevertheless ductile and strong. Although, Hastelloy A, B and C alloys can be gas welded or arc welded, the castings of these alloys are generally welded by the oxy-acetylene process using a neutral flame and a welding rod of the same composition as the base metal. In welding Hastelloy A, however, the welding rod is usually Hastelloy B to obtain better corrosion resistance in the weld. Any carbon pick-up from the flame will effect the corrosion resistance of the weld, and marked precautions should be taken. Hastelloy D and Illium G castings are gas welded with an excess acetylene flame and welding rod of the same composition as the base material is used.

Electric Arc Welding

Electric arc welding is performed by the metal-arc in preference to the carbon-arc. The carbon-arc, if desired, can be used for intermediate gages (0.037- to 0.062-in.) but is definitely not to be used for the Hastelloy alloys due to harmful carbon pick up. The heat of arc welding is more closely locallized than in gas welding, resulting in less distortion and less effect on the adjacent parent metal. Practically, with the exception of a possible slight grain enlargement in a very narrow band at the edge of the weld, there is no harmful effect on the parent metal from the heat of electric arc welding. Ductility and strength remain unchanged.

Although preheating is generally recommended in all welding operations, it is really not required for arc welding wrought nickel, Monel or Inconel, unless the temperature should drop to freezing or below. Then it is best to preheat the joint to about room temperature for 6-in. on both sides of the welding groove. In repair welding of castings it is always desirable to warm up before welding.

Welding electrodes of the heavily coated, shielded-arc type are used and are in general of the same composition as the material to be welded. The electrodes are used only on reversed polarity, i.e., the electrode is positive and the work is negative. (The electrode for Inconel, however, is an a.c.-d.c. rod.) A direct current motor generator or rectifier type welder is used. It is recommended that the diameter of the shielded-arc electrode be approximately the thickness of the sheet being welded, up to about 3/16 in., and that either a 5/32- or 3/16-in. electrode be used for heavier gages. Maintenance of a uniformly short arc and a slight slow weave across the seam is desirable if maximum and uniform penetration and also protection of weld metal are to be obtained.

Resistance Welding

Electric resistance methods of welding (spot, seam and flash welding) are applicable to the high nickel wrought alloys in sheet or strip form. Although their melting points are close together, there is a large difference in the electric resistivity and thermal conductivity in these alloys (See Table 3), necessitating different set-ups and adjustments in technique for each of the materials. Nevertheless, high electric resistivity which is especially associated with the high nickel alloys containing chromium and molybdenum, requires less electric current for resistance welding. Nickel has about the same electric resistivity and thermal conductivity as steel. In most cases energy input is about 2 to 2.5 times that required for mild steel of the same gage. These wrought alloys can be joined by the electric resistance methods not only to themselves but also to various other materials such as carbon and low alloy steels, stainless steel, brasses, bronzes and other copper alloys.

It is claimed that a flat electrode tip gives better results than a dome tip, and the flat tip should have a 30-deg. bevel edge to maintain the diameter of the flat surface. Tip diameters range from 1/8-in. for 0.025-in. sheet to 5/16-in. for material 0.062-in. thick. Electrode pressures must be great enough to give intimate contact and sufficient to eliminate molten metal completely from the weld, but not so great as to result in distorting the joint.

Atomic Hydrogen Welding

This method of welding, utilizing the high temperature of burning hydrogen gas between tungsten electrodes, is used for special work only, especially limited to the automatic production of welded tubing. This process requires no filler rod and produces a uniform penetration with a very flat outer surface. It is used successfully on Hastelloy A and Hastelloy B, but not on Hastelloy C sheets, which harden too rapidly alongside the weld. The high heat developed by this process keeps much of the adjacent metal in the hardening range for appreciable time, and cracking may develop due to any severe tensile strains on cooling. Hydrogen is soluble in molten nickel and can lead to considerable porosity in the weld with resultant lowering of strength.

Welding Rods and Wire

Welding rods and wire are in general of the same composition as the alloy being welded to insure uniform corrosion resistance without galvanic effects. The International Nickel Co. supplies welding rod and wire for gas and electric arc welding of Inco high nickel alloys. These materials are shown in the table below:

The Haynes Stellite Co. supplies welding rods of their alloys conforming to Hastelloy B, C and D. For the welding of Hastelloy A, rods of Hastelloy B are used. The Burgess-Parr Co. supplies Illium welding rods to weld Illium G.

Material	Wire or Rod	Type of Welding	Application
Nickel	"41" nickel gas-welding wire	Oxyacetylene	General purpose. No flux required
	"131" nickel welding electrode, d.c.	Metallic-arc	General purpose
	"51" nickel wire	Submerged melt	General purpose
"L" Nickel	"136" nickel welding electrode, d.c.	Metallic-arc	General purpose
Monel	"40" Monel gas-welding wire	Oxyacetylene	General purpose. Use with Inco "1" gas-welding and brazing flux. A silicon-Monel gas-welding wire for heavy sections of Monel acid pickling service.
	"43" Monel gas-welding wire	Oxyacetylene	
	"130X" Monel arc-welding electrode, d.c.	Metallic-arc	All welding
"K" Monel	"50" Monel wire	Submerged-melt	General purpose
	"44" "K" Monel gas welding wire	Oxyacetylene	General purpose. Use with 2 parts Inco "2" gas-welding flux and 1 part lithium fluoride
	"134" "K" Monel arc-welding electrode, d.c.	Metallic-arc	General purpose
Inconel	"42" Inconel gas-welding wire	Oxyacetylene	General purpose. Use with Inco "2" gas-welding flux
	"132" Inconel arc-welding electrode, a.c.-d.c.	Metallic-arc	General purpose
	"52" Inconel wire	Submerged melt	General purpose
Nickel-Clad Steel	"131" nickel arc-welding electrode, d.c.	Metallic-arc	Welding of nickel side only
"L" Nickel-Clad Steel	"136" nickel welding electrode, d.c.	Metallic-arc	Welding of nickel side only
Monel-Clad Steel	"130X" Monel arc-welding electrode, d.c.	Metallic-arc	Welding of Monel side only
Inconel-Clad Steel	"133" 80/20 nickel-chromium welding electrode, a.c.-d.c.	Metallic-arc	Welding of Inconel side only

General Welding Information

High nickel alloys can be welded by the oxy-acetylene, the electric arc (metallic-arc) or by electric resistance methods. Because of the low temperature of the oxy-hydrogen flame this method of welding is not practical. Hammer welding is not possible because union does not occur unless the metal is actually melted. Carbon-arc welding, although practical, has been displaced by the more efficient metallic-arc welding owing to the highly improved metal-arc welding electrodes. The atomic hydrogen and the Unionmelt submerged metal welding methods are used for special purposes only. Most of the present day welding is being done by the metal-arc or oxy-acetylene methods, and the same procedure and practice used for steel are applicable for the high nickel alloys with only slight modifications to ensure adequate fusion and penetration owing to the different physical and mechanical properties of these alloys.

Castings of all these alloys, except "H" Monel and "S" Monel, can be welded satisfactorily by any of the above methods. Joining of "H" Monel and "S" Monel castings by welding is not recommended because of a tendency toward cracking.

For the properly welded Inco alloys no thermal or chemical (passivation) aftertreatment is needed to retain or restore corrosion resistance, since the joints are equivalent in corrosion resistance and strength to the parent metal. Specific thermal treatments for stress-stabilizing anneal or for age-hardening of the hardenable alloys are used and recommended. The Hastelloy alloys should be given a full anneal after welding to restore their maximum corrosion resistance and to overcome any hardening or embrittling that may have occurred beside the welds where the sheet was held in the hardening range of 1200 to 1900 F.

Joining by Riveting

In discussing the joining of the high nickel alloys the various methods of soldering, brazing and welding have been covered. However, there is still another practical way of joining and that is by riveting either hot or cold. The method is not much different than that used for riveting steel, except when hot riveting the same precautions apply as when heating the alloy for hot working.

Rivets of 5/16-in. diameter and smaller are usually driven cold. The holes for the rivets should be subpunched and reamed to size to remove material strained in punching, or should be drilled to size. It is recommended for hot riveting to heat nickel and Monel to 1600 to 1700 F when using hydraulic equipment, and to heat nickel, Monel and Inconel to 1900 to 2100 F when using pneumatic equipment. Inconel must be heated to the upper temperature range for either type of riveting hammer to avoid the 1600 F red short point.

With rivets of suitable temper and with proper riveting the driven head should be as strong as the shank.

Calking of riveted seams in plate is necessary to close them against leakage. Calk welding by the electric arc can be employed to close riveted joints in plates that are too thin for tight calking, and for the protection of the exposed steel in lap joints of nickel-clad plate.

Cleaning and Pickling

As with other base alloys the types of oxide produced in nickel-base alloys vary with the composition and heating conditions. Thus, the proper pickling solution for each case must be chosen accordingly. The nickel oxide film on metal that has been properly heated is formed during contact with the air after the work is drawn from the furnace. Hot-forgings, hot-headed bolts, hot-rolled and hot-formed products, and annealed metal cooled in the air are all subject to oxide skin formation. Chromium-bearing nickel base alloys form a superficial chromium oxide film. The oxide films are all thin and tightly adherent. With improper heating heavy oxide films and scale may result.

Drawn or spun parts, cold-headed rivets, cold-drawn wire and other cold-worked products finished by annealing in a strongly reducing sulfur-free atmosphere and either cooling out of contact with air or quenching in a 2% alcohol-water solution may develop a slight discoloration or tarnish that will require pickling or brightening. Some materials acquire a brown discoloration when machined at high speeds with sulfur-base cutting oil because of the formation of sulfur compounds. The surface of the metal may be attacked during heating if sulfur is in the atmosphere or if the hot parts come into contact with sulfur compounds in the furnace hearth or sulfur-containing paint and marking pencils or even oil or grease from the last mechanical operation. In any case the metal has to be cleaned and pickled before service. Thorough cleaning of the parts of all oil, grease and dirt is essential before pickling.

Cleaning and Degreasing: Grease, oil, fats and lubricants can be removed before pickling by standard cleaning methods. Soluble oils can be removed with soap and hot water. Tallow, fats and fatty acids are removed with a hot 10 to 20% soda ash or caustic soda solution; while mineral oils and greases are removed by immersion in any organic solvent as carbon tetrachloride and kerosene, followed by a final dip in caustic soda or trisodium phosphate.

Tarnish Removal by Flash Pickling: Cold-worked products after proper annealing in a sulfur-free atmosphere develop slight discoloration or tarnish. A bright, lustrous white finish can be obtained by flash pickling or bright dipping. The recommended pickling bath for Monel and "K" Monel contains 1 gal. water, 1 gal. 38 deg. Be. nitric acid, and 1/2 lb. sodium chloride, maintained at 70 to 100 F for 5 sec. maximum immersion; while the bath for nickel and "Z" nickel contains 1 gal. water, 1½ gal. 66 deg. Be. sulfuric acid and 2¼ gal. 38 deg. Be. nitric acid plus ¼ lb. common salt maintained at 70 to 100 F for 5 to 20 sec. immersion. Inconel cannot be flash pickled without first descaling.

Reduced Oxide Removal: Hot-worked products develop oxide films, which after annealing in a sulfur-free atmosphere, are converted into rather spongy and lightly adherent layers. This spongy layer on nickel is reduced metallic nickel, and on Monel it is a mixture of reduced metallic nickel and copper. Since the oxide film on Inconel does not respond to complete reduction but is reduced selectively to a mixture of metallic nickel and chromium oxide, it becomes difficult to pickle. Nickel, Monel, "K" Monel and "Z" nickel are pickled in a solution containing 1 gal. water, ¾ pint 66 deg. Be. sulfuric acid and ½ lb. sodium nitrate held at 180 to 190 F for 30 to 90 min. immersion.

Oxide Film or Scale Removal: When hot forgings, hot-rolled or hot-formed parts are annealed and allowed to cool in air, moderately thick and tightly adherent oxide films form on all the alloys during contact with the air. Monel and "K" Monel are pickled in a bath containing 1 gal. water, 1.2 gal. 20-deg. Be. hydrochloric acid, and ¼ lb. cupric chloride maintained at 180 F for 20 to 40 min. immersion, then rinsed in hot water and immersed in a second bath containing 1 gal. water, $^{1}/_{10}$ gal. 66-deg. Be. sulfuric acid, $1^{1}/_{10}$ gal. sodium dichromate maintained at 70 to 100 F for 5 to 10 min. Nickel and "Z" nickel are pickled in a solution containing 1 gal. water, ½ gal. 20-deg. Be. hydrochloric acid, ¼ lb. cupric chloride held at 180 F for 1 to 2 hr. immersion, followed if desired to brighten by a dip for a few seconds in a solution containing 1 gal. water, 1½ gal. 66-deg. Be. sulfuric acid, 2¼ gal. 38-deg. Be. nitric acid. Inconel is pickled in a solution of 1 gal. water, 1 gal. 38-deg. Be. nitric acid, 1¼ pint 40% hydrofluoric acid held at 70 to 100 F for 15 to 90 min. immersion.

Heavy Scale Removal: Sand blasting or grinding may be necessary to remove heavy scale, especially if the surface below the scale is rough and cracked. Following this with a flash pickle will brighten up the surface.

Hastelloy Alloys and Illium Pickling: Because of the greater tenacity of the oxide and scale on the surface of Hastelloy alloys pickling is more difficult, but can be done efficiently by immersion in a bath containing 18 parts water, 6 parts concentrated hydrochloric acid and one part concentrated nitric acid held at 200 F for about 20 to 30 sec. exposure, or in a solution of 10% sulfuric acid, 5% sodium nitrate and 5% sodium chloride held at 200 F for 30 to 60 min. Hastelloy C being more corrosion resistant than Hastelloy A or B will require longer pickling. Illium G is pickled in a solution of 10% nitric acid and 2% hydrofluoric acid at 100 F for a short time.

Discoloration Removal from Automatic Screw Machine Parts: During the high speed machining in the automatic screw machines using a sulfur-base cutting oil, brown discoloration may take place, especially on Monel. It can be removed by immersion in a bath containing ½ to 1 lb. sodium cyanide to 1 gal. water held at 70 to 100 F for 5 to 30 min.

Coppering: Unless proper precautions are taken during pickling operations coppering will occur occasionally on the high nickel alloys containing an appreciable amount of copper. Small amounts of nitric acid or ferric chloride added to the pickling bath will prevent it. The copper flash, if it does occur, can be removed readily by immersing in an aerated ammonia solution containing approximately 1 part of commercial aqua ammonia to 1 gal. water at room temperature for a minute or so.

Corrosion

Nickel and the high nickel alloys are especially characterized by their high resistance to all kinds of corroding media. They are highly corrosion resistant to most of the normal and special corroding agents found in industries. An attempt is made below to briefly outline the corrosion resistance of these alloys to various atmospheres and corroding media. For detailed test data and penetration test results the reader is referred to the manufacturer.

In general these alloys are not attacked by inside and outside atmospheres unless there is a sulfurous condition. Marine atmosphere may have slight effect, but rural and suburban atmospheres have no effect. Inconel remains bright and is not subject to fogging. Illium and the Hastelloy alloys remain bright. The nickel-copper alloys may take on a brownish to green tarnish in sulfur atmospheres, but there is no destructive corrosion.

All the alloys are completely resistant to any corrosion by fresh water.

Exposure to quiet and stagnant sea water will attack all the alloys through pitting, except Hastelloy C and Illium G. Agitated or rapid flowing sea water has less effect. The nickel-chromium-iron alloys are moderately resistant to rapidly flowing sea water, but the nickel-copper alloys have their greatest use in sea water under conditions of high velocity where resistance to effects of impingement and cavitation are important.

Alkalis: All the nickel-base alloys are practically resistant to the alkalis. Nickel has outstanding resistance to caustic soda. But ammonium hydroxide in concentrations over 1% will corrode nickel appreciably. The nickel-copper alloys can be used in ammonium hydroxide in concentrations up to 3%, while the nickel-chromium-iron alloys such as Inconel, resist all concentrations. In concentrated caustic soda at 800 F the chromium content of Inconel and the other chromium-bearing alloys makes them subject to corrosion.

Wet and Dry Gases: Dry gases at room temperature do not effect these alloys. Inconel is completely resistant to mixtures of steam, air and carbon dioxide. However, wet chlorine, bromine, sulfur dioxide will attack nickel, Monel and Inconel. Wet tric oxide and ammonia will corrode ickel and Monel. Both nickel and Inconel sist mixtures of nitrogen, hydrogen and mmonia in the nitriding process; Inconel is mewhat superior. Chlorine and hydron chloride will not attack nickel and nconel up to 1000 F and Monel up to 850 Gases of sulfur compounds will attack l the nickel-base alloys at elevated temeratures.

Neutral or Alkaline Salts: In general all e nickel base alloys are highly resistant to eutral or alkaline salts.

Oxidizing Salts: Nickel and the nickelopper alloys are attacked by oxidizing acid lts. The chromium containing alloys demnstrate useful resistance to these media. Nickel and Monel are not resistant to soluions containing appreciable percentages of erric, cupric and mercuric chlorides. Haselloy C has unusual resistance to ferric hloride up to 160 F and to cupric chloride up to 100 F. It also resists at moderate emperatures such mixtures of oxidizing alts as chromates and nitrates in sulfuric nd hydrochloric acid solutions. Illium G esists acid phosphates and acid sulfates, lso mixtures of oxidizing salts in acid soluions.

Oxidizing Alkaline Salts: Inconel is unffected by hydrogen peroxide solutions. Hypochlorites are less corrosive to Inconel than o Monel or nickel. It is recommended to avoid exposure to solutions containing more than 3 grams of available chlorine per liter and to use only when the exposure is part of a cyclic operation in which there is intermittent exposure to weak acid solutions. Hastelloy C possesses unusual resistance to oxiding solutions, especially those containing chlorides, and to hypochlorite solutions and moist chlorine.

Mineral Acids: Nickel and nickel-copper alloys resist air-free sulfuric acid under 80% concentration. Monel is good in boiling solutions in concentrations under 20%. Inconel has fair corrosion resistance to sulfuric and hydrochloric acids at atmospheric temperature, but is not used for hot or concentrated hydrochloric acid; in such cases, Hastelloy A or B are preferred. However, Inconel has the highest resistance to hydrogen sulfide solutions. Strong oxidizing acids as nitric acid attack nickel readily. Hastelloy A and B were developed primarily to resist hydrochloric acid, Hastelloy D resists concentrated sulfuric acid at elevated temperatures, while Illium G resists sulfuric acid under all conditions of concentration and temperature. Illium G is not recommended for strong or hot and dilute hydrochloric acid, but is used for phosphoric acid and hydrogen sulfide. Hastelloy C is highly resistant to all the mineral acids. Additions of small amounts of oxidizing salts as ferric sulfate or cupric sulfate to sulfuric acid solutions will increase the passivity range of the nickel-chromium-iron alloys.

Oxidizing Acids: Nickel is attacked by oxidizing acids as nitric acid, and so are the nickel-copper alloys except in concentrations below 1% at room temperature. Inconel and the nickel-chromium-iron alloys are highly resistant to these acids at moderate temperatures, and the higher the chromium content the wider the range of concentration and temperature in which passivity exists. Sulfurous acid solutions, especially when hot, attack nickel and Monel but are resisted by the chromium-containing alloys. Hastelloy C is resistant to dilute nitric acid up to 150 F, and to concentrations over 40% only at room temperature. Hastelloy A, B and D are not recommended for nitric acid or other strongly oxidizing acids. Both Hastelloy C and Illium G resist acid mixtures of nitric and sulfuric acids, chromic and sulfuric acids, sulfuric and dichromates, permanganates and persulfates, and similar combinations. Illium G resists all concentrations of sulfuric acid and nitric acid over a wide range of temperatures.

Organic Acids and Compounds: Neutral and alkaline organic compounds have no effect on nickel, but organic acids do corrode it moderately. The nickel-copper alloys have good resistance to organic acids, neutral and alkaline organic compounds, as well as fruit and other food acids. The nickel-chromium-iron alloys have complete resistance to organic acids as occur in food products, are only fairly resistant to hot, concentrated organic acids as acetic and formic acids, but are particularly resistant to fatty acids at elevated temperatures. The Hastelloy alloys and Illium resist all organic acids and neutral and alkaline organic compounds.

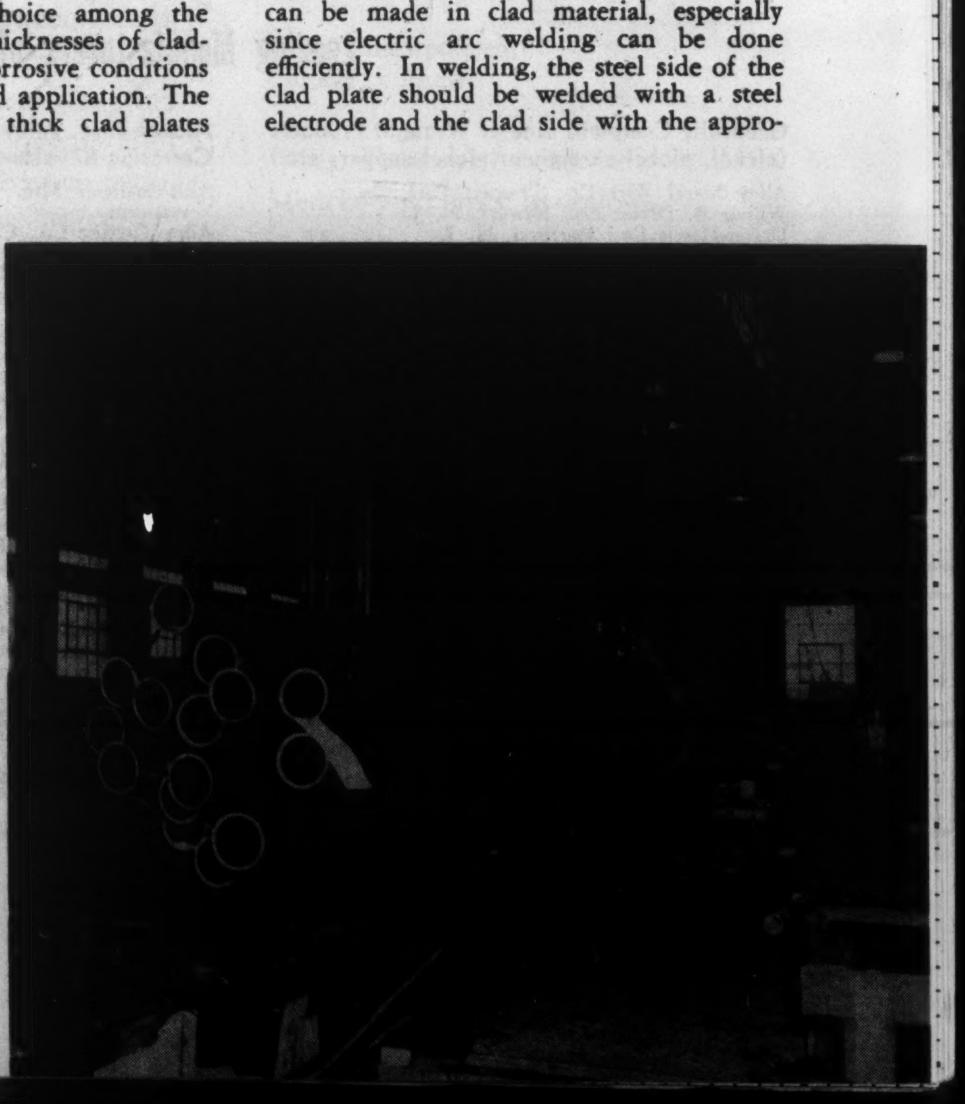
Available Forms

The high nickel alloys are available in the forms shown in Table 11. Most of the alloys can be supplied in the wrought and in the cast condition, but several of the alloys can be supplied only in the cast condition. Special cold-rolled sheets and strip of some of the alloys can be furnished to suit the purchaser's requirements. The material that can be hot-rolled or forged is available in rounds, hexagons, squares, angles, flats, half rounds and ovals. Similarly cold-drawn materials are available in rounds, hexagons, squares, flats and angles. Castings can be obtained as cast-to-shape or as standard cast fittings. All the alloys, except "H" Monel and "S" Monel are also available as welding wire or coated welding rod. Usually the welding wire is bare for gas-welding and coated (shielded) for arc-welding.

In addition, the hot-rolled, cold-rolled and cold-drawn material can be mill supplied in various tempers and different finishes. Hot-rolled products direct from the mill may carry a thin coating of black oxide or may be pickeled to remove this oxide film. Seamless tubing can be obtained in three tempers: "as-drawn," "normalized" and "soft." Cold drawn tubing can also be obtained in ground and polished finish.

Clad Plate: Clad plate is steel plate, usually "flange" quality, protected on one or both sides by a dense, homogeneous layer of nickel, Monel or Inconel. The material is bonded firmly to the steel plate by hot rolling and does not separate during fabrication or forming operations, nor during pressure and temperature changes. The thickness of clad is a substantial portion of the total plate thickness. The composite plate, of a total thickness of 3/16-in. or more, is produced with thicknesses of cladding of 5, 10, 15 and 20%. The 5% cladding is produced only on ½-in. thick or heavier plate. The choice among the three compositions and thicknesses of cladding to meet particular corrosive conditions is governed by service and application. The availability of wide and thick clad plates makes possible the construction of equipment as storage tanks, evaporators and tank cars with a corrosion resistant inner surface free from the many disadvantages of thin loose linings.

The material responds readily to hot and cold forming, spinning, pressing and bending. Therefore, any desired shape or form can be made in clad material, especially since electric arc welding can be done efficiently. In welding, the steel side of the clad plate should be welded with a steel electrode and the clad side with the appro-



These extruded and cold drawn Monel tubes are 36-ft. long, 5 9/16-in. o.d. with ¼-in. wall thickness. (Courtesy: International Nickel Co.)

priate nickel or nickel alloy welding rod.

Pipe and Tubing

Pipe and tubing can be supplied in seamless, welded or cast condition, depending on the alloy composition. Seamless cold drawn Nickel and Monel tubing are produced in outside diameters from ¼ to 1½ in. by 1/16-in. increments, and from 1⅜ to 5 in. by ⅛-in. increments. Inconel is produced from ½ to 4 in. diameter with the same increments. Tube walls are drawn to thicknesses from 0.025 to 0.300 in. for nickel and Monel, and from 0.035 to 0.259 in. for Inconel. The tubing is redrawn to smaller sizes by producers of small tubing. Heavier walls and larger diameters have recently been made available as an extruded product.

Seamless nickel and Monel pipe are produced in standard iron pipe sizes from ⅛ to 6 in. in extra heavy from ⅛ to 4 in., and in double extra heavy from ¾ to 1¼ in. Seamless Inconel pipe is produced in standard iron pipe sizes from ¼ to 3½ in., and extra heavy from ⅜ to 2 in.

Inco welded tubing produced by forming and welding strip is available in sizes from ¼ to 2 in. for wall thicknesses from 0.032 to 0.095 in. Welded tubing in Hastelloy A and B is available from ½ to 2-5/16 in. external diameter with wall thickness of either 0.109 or 0.065 in.

These alloy tubes respond readily to the forming and fabricating operations of coiling, bending, threading, expanding and joining.

Cold-drawn tubing is drawn cold to size in several passes, with frequent intermediate annealing, starting with hot-rolled, annealed and pickeled tubing. It is straightened and tested under hydraulic pressure that is varied in magnitude according to the tube size. The Inco alloy tubing are usually supplied in "normalized" temper, but they can also be obtained in the "as-drawn" and "soft" tempers.

TABLE 11—AVAILABLE FORMS

Material	Cold Rolled Sheet, Strip	Cold Drawn Rods, Bars, & Wire	Seamless Tube & Pipe	Welded Tube & Pipe	Forged Billets, Shapes	Hot Rolled Plates,		Hot Rolled Rods, Bars	Hot & Cold Rolled Angles	Castings & Cast Fittings
						Solid	Clad Steel			
Nickel	x	x	x	x	x	x	x	x	x	x
"L" Nickel	x	x	x	x	x	x	x	x	x	
"D" Nickel	x	x	x		x	x		x	x	
"Z" Nickel	x	x	x		x	x		x		
Monel	x	x	x	x	x	x	x	x	x	x
"R" Monel		x						x		
"K" Monel	x	x	x		x	x		x		
"KR" Monel		x						x		
"H" Monel										x
"S" Monel										x
Inconel	x	x	x	x	x	x	x	x	x	x
Hastelloy A		x		x	x	x		x		x
Hastelloy B		x		x	x	x		x		x
Hastelloy C				x		x				x
Hastelloy D										x
Illium G										x
Illium R										x

Leading Manufacturers of Nickel and Nickel-Base Alloys

Generally Complete Line of Wrought Products (nickel, nickel-chromium, nickel-copper, etc.)

Alloy Metal Wire Co., Prospect Park, Pa.
Wilbur B. Driver Co., Newark, N. J.
Driver-Harris Co., Harrison, N. J.
Hoskins Mfg. Co., Detroit
International Nickel Co., Inc., New York
C. O. Jelliff Mfg. Co., Southport, Conn.

Nickel Alloys for Electrical and Thermostatic Uses

All of the foregoing, plus:

Allegheny Steel Corp., Brackenridge, Pa.
Callite Tungsten Corp., Union City, N. J.
Carpenter Steel Co., Reading, Pa.
W. M. Chace Co., Detroit
General Plate Div., Metals & Controls Corp., Attleboro, Mass.
D. E. Makepeace Co., Attleboro, Mass.
Sirian Wire & Contact Co., Newark, N. J.
I. Stern & Co., New York
Westinghouse Electric Corp., Pittsburgh
H. A. Wilson Co., Newark, N. J.

Nickel-Chromium-Moly or Nickel-Molybdenum-Iron Alloys

Burgess-Parr Co., Freeport, Ill.
Haynes Stellite Co., Kokomo, Ind.

Nickel-Base Alloy Castings for Heat- and Corrosion-Resistance

Allis-Chalmers Mfg. Co., Milwaukee (precision investment)
Alloy Casting Co., Champaign, Ill.
Arocast Corp., Summit, N. J. (precision investment)
Atlas Foundry Co., Irvington, N. J.
Austenal Laboratories, Inc., New York (precision investment)
Babcock & Wilcox Co., New York
Bergen Precision Castings, Inc., Pleasantville, N. Y. (precision investment)
Calorizing Co., Wilkinsburg, Pa.
Chicago Steel Foundry Co., Chicago
Cooper Alloy Foundry Co., Elizabeth, N. J.
Driver-Harris Co., Harrison, N. J.
Duraloy Co., Inc., Dayton, Ohio
Electro-Alloys Div., Elyria, Ohio
Fahralloy Co., Harvey, Ill.
General Alloys Co., Boston
Haynes Stellite Co., Kokomo, Ind. (precision investment)
Hoskins Mfg. Co., Detroit
International Nickel Co., Inc., New York (includes precision investment)
Kerr Mfg. Co., Detroit (precision investment)
Lebanon Steel Foundry Co., Lebanon, Pa.
Michiana Products Corp., Michigan City, Ind.
Michigan Steel Casting Co., Detroit (includes precision investment)
Midvale Co., Philadelphia
Midwest Foundry Div., Coldwater, Mich. (precision investment)
Ohio Steel Foundry Co., Springfield, Ohio
Pacific Foundry Co., Ltd., San Francisco
Sivyer Steel Casting Co., Milwaukee
Standard Alloy Co., Cleveland
Sterling Alloys, Inc., Woburn, Mass.
Swedish Crucible Steel Co., Detroit
J. R. Wood Products Corp., New York

Nickel-Base Ingot Metal

Ajax Metal Co., Philadelphia
American Nickel Alloy Mfg. Co., New York
Belmont Smelting & Refining Co., Brooklyn
Federated Metals Div., A. S. & R. Co., New York
Metallurgical Products Co., Philadelphia

Miscellaneous Special Nickel Alloy Products

American Nickeloid Co., Peru, Ill. (preplated strip)
Apollo Metal Works Co., Chicago (preplated strip)
Bundy Tubing Co., Detroit (tubing)
Lukens Steel Co., Coatesville, Pa. (nickel-clad sheet)
Somers Brass Co., Inc., Waterbury, Conn. (bright nickel strip)
Superior Tube Co., Collegeville, Pa. (fine tubing)

Warehouses and Distributors of Nickel and Its Alloys

Metal Goods Corp., St. Louis, Mo.
Whitehead Metal Products Co., Inc., New York
Williams & Co., Inc., Pittsburgh

CONTENTS NOTED

A monthly department dedicated as a forum for the interchange of ideas between readers and editors. All readers are urged to take advantage of this space and participate in the discussions presented.

ard Chromium Plate

o the Editor:

In "Hard Chromium Plate and Its ses" in the October issue of MATE- IALS & METHODS, Mr. Hosdowich sts comparisons of service life that e unquestionably correct for specific stance, but which to me are misading if regarded as representative f general practice. It is from this andpoint that these comments are ade.

eamers and Twist Drills

Chromium plating for size restorg is often less expensive than new rills, especially in the large sizes. n drilling, hard chromium does not ay on the actual cutting edge long nough to have much effect upon e cutting life. It does not enable e built up edge to free itself of the dhesion. Plated and polished flutes ngthen life because they lower rictional resistance of the chip after is cut. It helps to lift out the chips, ermit coolant to be more effective, ve the power spent in crushing up nd compacting the chips, prevent ese chips from causing rough and versize holes. When the same flute olishing care is given the flutes of igh-speed steel drills or reamers, the esults are very close together.

rawing Punches and Dies

Chromium plating frequently is a olution to galling in the die or stickg to the punch. This is a lazy way ut of finding the solution of the drawing lubricant problem. It is often cheaper to restore worn punches by plating than to scrap them. Some steels, such as graphitic steels, will so far outdraw chromium plated punches that size restoral is not warranted. On dies, tungsten carbide or sometimes graphitic steels so far exceed plating that restoral is not profitable.

Calender Rolls

As far as paper, rubber and printing ink manufacture is concerned, the roll life of 2 to 3 weeks that Mr. Hosdowich cites should be taken as either sub-normal rolls or abnormal service. Upper calender rolls of hardened steel or chilled cast iron normally run many years between grinds, and bottom roll life is one to two years. Paper mills frequently regrind lower rolls during the repair shut down period as a preventative maintenance activity.

Taps

Those who have made threaded munition parts have reason to be devotees of hard chromium plating. They know that two taps can measure identically and be put in the same tapper and still vary when the tapped holes are gaged. Such a shop buys high-speed steel taps, a bottle of etching acid and finds a source of supply of hard chromium plating. If the tap cuts oversize, he etches it down a bit until its output passes the gage and lets it run until it is undersize, then has it very lightly plated with chromium to put it back on the job. His only worry is plating it too much. If you have not experienced this usage it is indeed a new appreciation of an old usage.

The process engineer does not have trouble in distinguishing between hard and soft chromium plate. "Soft" chrome is a thin decorative coating usually to be polished. "Hard" chromium is put on hard materials for size or wear treatment. "Thick chromium plate" is then a confusion because the size restorative coat on a fine thread top is often 0.0003 in. and seldom more than 0.001 in. and you cannot call that a thick chromium plate.

George M. Mencke,
Chief Engineer

Permo, Incorporated,
Chicago, Illinois

Mr. Hosdowich comments on Mr. Mencke's remarks, as follows:

"As you request, I am giving my comments on the letter from Mr. Mencke which you enclosed.

"Mr. Mencke's comments and criticisms should be of interest to readers of the original article. His paragraph on taps is a valuable addition and corroborates the experience of United Chromium, Inc. However, it appears that his discussion on chromium plated tools is based entirely on the cutting and forming of steel. As pointed out in the original article, chromium plated cutting tools are especially advantageous when used

(Continued on page 1495)

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CONTENTS NOTED

Continued from page 1493

cutting materials such as plastics,
d rubber, copper, brass, and alumi-
n. Less improvement is shown
en cutting cast iron, and least
en cutting steel.

We should like to correct his
ement that chromium does not
on the cutting edge of drills
g enough to have much effect on
service life. It is good practice to
nd the drill before it is used, thus
noving the 'built up' edge to
ich Mr. Mencke refers. The cut-
g edge then has chromium on the
te side supported by steel on the
her side. A new chromium cutting
ge is formed each time the drill is
ound. The flutes are not polished
er chromium plating, as he indi-
tes, and the lower frictional resist-
ce is not due to polishing but to
low coefficient of friction of the
romium.

"He says that chromium plating
es is a lazy way out of finding the
lution to the drawing lubricant
oblem. Evidently there is much to
learned on this subject, and we
ggest that the editor invite Mr.
encke to write an article on draw-
g lubricants. Where galling and
ratching are problems, chromium
ated dies are preferable to graphitic
el dies regardless of service life.
the case of a chromium plated
awing die, for example, the im-
oved finish on the tube is often of
eater value to the manufacturer
an the increased life of the die.
hen the finish is of no interest, the
ze of the die and the production
requirements determine which is more economical, the chromium plated die or the tungsten carbide die.

"The only reason for including comparative figures of service life is that the reader is generally more interested in a few definite figures than in vague generalities. These figures are reports of representative cases and were not meant to be taken as general averages over entire industries.

"In his last paragraph, Mr. Mencke mentions that decorative chromium plating is usually polished. The fact is that correctly plated decorative chromium is *not* usually polished or buffed. He also mentions that referring to 'hard chromium plate' as 'thick chromium plate' is a confusion because in some cases it is only from 0.0003 in. to 0.001 in., which could not be called thick. While not thick in comparison with many hard chromium applications where 0.005 to 0.010 in. are used, it is many times thicker than the usual decorative chromium plate, which is only 0.00001 to 0.00002 in. in thickness. The point is that in either hard chromium plate or decorative chromium plate, the chromium itself is electrodeposited in the same way and is of the same hardness, the difference between the two general types being in the thickness."

J. M. Hosdowich,
Chief Chemist

United Chromium, Inc.,
New York 17, N. Y.

We are sure that this discussion will be of interest to all who read the original article in our October issue.—The Editors.

Safety With Solvents

To the Editor:

In your article under date of October 1946, "The Safe Handling of Solvents," the writer did an excellent and a most thorough job of pointing out the toxic nature of many of these solvents and the saftey hazards involved.

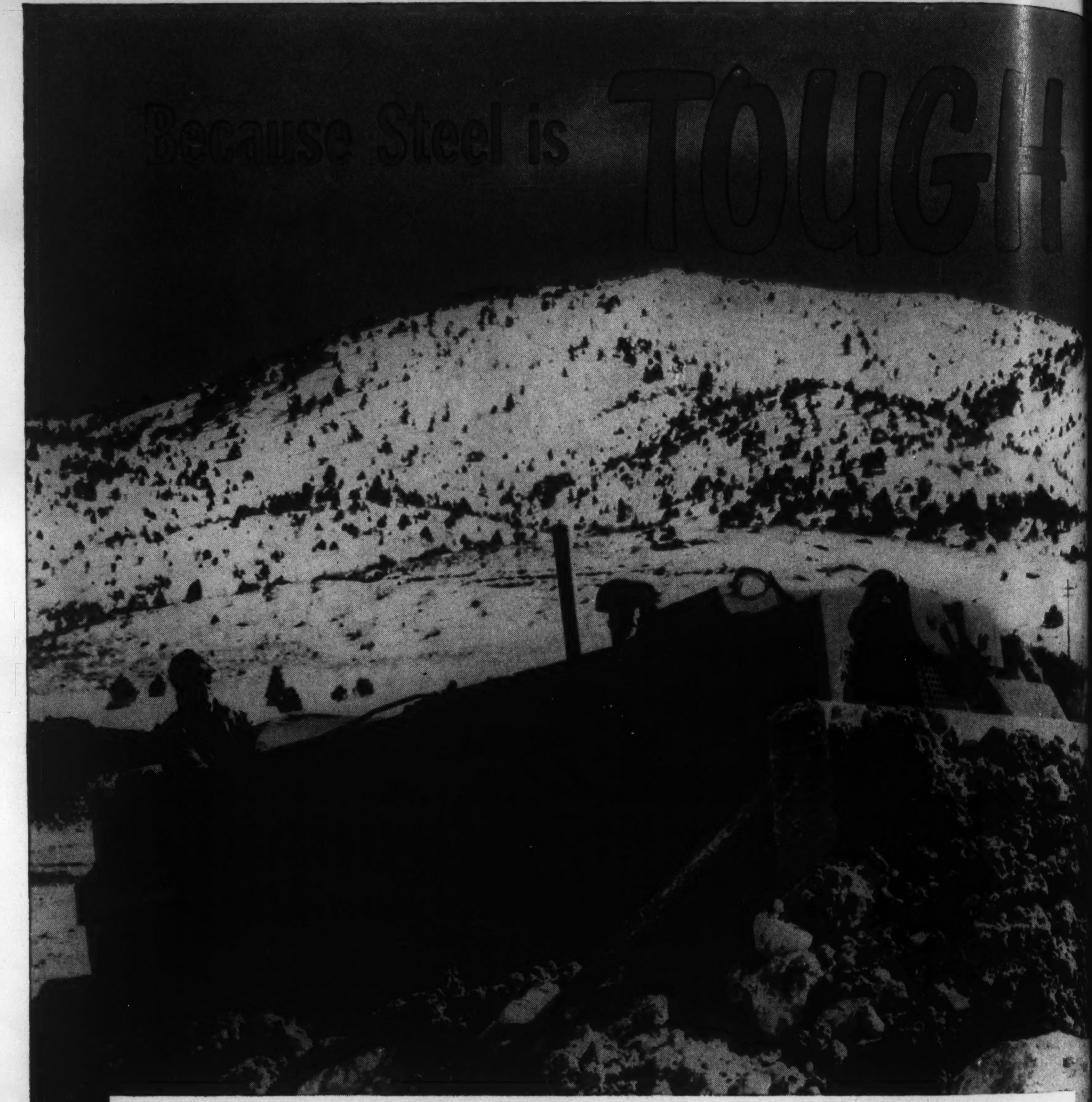
In the paragraph entitled "Personal Protection" in this article, the writer made the statement that respirators were of three general types: the canister gas mask, the supplied air type, and the self-contained type, *which carries its own oxygen supply.*

May we point out that the use of a self-contained oxygen breathing apparatus in the presence of any oily atmospheres could be highly dangerous. Our own company manufactures self-contained breathing apparatus using *pure compressed air* from high pressure cylinders, eliminating the danger of using oxygen in the presence of oily vapors.

Earle M. Scott,
President

Scott Aviation Corp.,
Lancaster, N. Y.

Our thanks to Mr. Scott for pointing out another means of assuring absolutely safe working conditions when handling toxic solvents.—The Editors.



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MATERIALS & METHODS Engineering File Facts

NUMBER 126
December, 1946

METHODS: Test Methods

ASTM Specifications Covering Mechanical Testing of Metals

Specification Number	Title	Scope of Specification
A256-42T	Compression testing of cast iron	Dimensions of test specimens and procedure
A260-42T	Torsion tests of cast iron	Dimensions of test specimens and procedure
B95-39	Test for linear expansion of metals	Test method for determining the expansion of oxidation resistant alloys at temperatures up to 1000 C (1830 F); apparatus, test specimens, procedure for standard and rapid test methods, and the reporting of data
B113-41	Bend testing of wire	Methods for bend testing round wire from 0.010 to 0.117 in. in dia. and rectangular and flattened wire not over 0.117 in. in thickness where the ratio of width to thickness does not exceed 10
B118-42T	Testing nickel and nickel-alloy wire and ribbon for electronic tube filaments	Apparatus and procedure for testing the physical and electrical properties
B153-45	Expansion (pin test) of copper and copper-alloy tubing	Apparatus, test specimen and procedure
B155-45T	Temper of strip and sheet metals for electronic devices	Procedure for determining the temper of sheet and strip in thicknesses of 0.020 in. or less by "spring-back" method
B156-42T	Testing lateral wire for grids of electronic devices	Procedures for determining properties of wire 0.001 to 0.010 in. in dia.
B157-45T	Testing wire for supports used in electronic devices and lamps	Methods for determining properties of round wire (exclusive of molybdenum and tungsten) from 0.010 to 0.075 in. in dia.
B191-44T	Equivalent yield stress of thermostat metals	Apparatus, dimensions of test specimens and test procedure
E4-36	Methods of verification of testing machines	Verification methods, definitions, permissible variations, reports, and certificates of verifications
E6-36	Terms relating to methods of testing	Standard definitions
E8-42	Tension testing of metallic materials	Dimensions of standard tension test specimens (plate, sheet, ½-in. dia., cast iron, malleable iron, die castings, rod, wire, tubing and welded test specimens), definitions, speed of testing, and test procedures
E9-33T	Compression testing of metallic materials	Apparatus, speed of testing, dimensions of 3 classes of compression test specimens, and procedure
E10-27	Test for Brinell hardness of metallic materials	Apparatus, procedure, and tables of Brinell hardness numbers
E16-39	Bend testing for ductility of metals	Test specimens and procedures
E18-42	Test for Rockwell hardness and Rockwell superficial hardness of metallic materials	Apparatus, calibration, procedure, use of standard and superficial Rockwell hardness testers
E21-43	Short-time elevated temperature tension tests of metallic materials	Apparatus, test specimens, temperature control and measurement, and the reporting of data
E22-41	Long-time high temperature tension tests of metallic materials	Creep test procedures, and reporting of data
E23-41T	Impact testing of metallic materials	Apparatus, dimensions of test specimens, and procedure
E33-42	Hardness conversion table for cartridge brass	Tables giving relationship between DPH, BHN and Rockwell hardness values for cartridge brass
E48-43T	Hardness conversion tables for steel	Tables giving relationship between DPH, BHN and Rockwell hardness values for steel

Compiled by Robert S. Burpo, Jr., from "ASTM Standards, 1944, Part I", and "ASTM Standards, 1945 Supplement, Part I", published by the American Society for Testing Materials, Philadelphia, Pa.

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MATERIALS & METHODS Engineering File Facts

NUMBER 127
December, 1946

MATERIALS: Corrodability of Metals and Alloys

Relative Corrodability of Metals and Alloys

(Electromotive Series)

Corrosion of two different metals or alloys in contact often results if they become wet. Dampness or condensation of moisture upon the junction of dissimilar metals sometimes is sufficient to cause destructive corrosion to take place. In the table below are listed many common metals and alloys in their order of electrochemical activity. It is to be noted that intergranular attack, and the effects of internal and applied stresses (especially the damaging effects of alternating stresses applied in the presence of a corrosive atmosphere) on the life and load-carrying capacity of metals are not considered in this table.

	Material	Remarks
Anodic End	Magnesium	The more anodic metal of a pair will undergo destructive corrosion, while the more cathodic metal may not. If the area of the corroding (anodic) material is large compared with that of the cathodic material, the damage will be spread over a large area and the destructive effects are lessened. Metals above hydrogen are attacked by both HCl and dilute H_2SO_4. Certain metallic materials are, under some conditions, active and under others, passive. While in the passive condition they exhibit corrosion resistance similar to that of the materials appearing below hydrogen in the electromotive series. Conversely, when active they are rated nearer the anodic end of the series. Sometimes these active-passive materials will be active if their areas are relatively small, and passive if their areas are relatively large. These active-passive materials are starred (*) when they are in the positions they occupy as active materials; when they are in the positions they occupy as passive materials, they are double starred (**).
	Magnesium alloys	
	Aluminum (pure and alclad)	
	Zinc	
	Cadmium	
	Aluminum alloys	
	Chromium	
	Carbon steel	
	Copper bearing steel	
	Cast iron (gray)	
	Chromium steel (4 to 6% Cr)	
	Chromium steel (12 to 14% Cr)*	
	Chromium steel (16 to 18% Cr)*	
	Chromium steel (23 to 30% Cr)*	
	Nickel-chromium-copper cast-iron (1)	
	Nickel-chromium steel (7% Ni, 17% Cr)*	
	Nickel-chromium steel (8% Ni, 18% Cr)*	
	Nickel-chromium steel (14% Ni, 23% Cr)*	
	Nickel-chromium steel (20% Ni, 25% Cr)*	
	Nickel-chromium-molybdenum steel (12% Ni, 18% Cr, 3% Mo)*	
	Lead-tin solder	
	Lead	
	Tin	
	Nickel*	
	Nickel-chromium-iron alloy (62% Ni, 15% Cr, 23% Fe)*	
	Nickel-chromium-iron alloy (79% Ni, 14% Cr, 7% Fe)* (2)	
	Nickel-chromium alloy (80% Ni, 20% Cr)*	
Neutral Point in Series →	Hydrogen	
Cathodic End	Brasses	
	Copper	
	Bronzes	
	Copper-nickel-zinc alloys (nickel silver)	
	Nickel-copper alloy (3)	
	Nickel**	
	Nickel-chromium-iron alloy (62% Ni, 15% Cr, 23% Fe)**	
	Nickel-chromium-iron alloy (79% Ni, 14% Cr, 7% Fe)** (2)	
	Nickel-chromium alloy (80% Ni, 20% Cr)**	
	Chromium steel (12 to 14% Cr)**	
	Chromium steel (16 to 18% Cr)**	
	Nickel-chromium steel (7% Ni, 17% Cr)**	
	Nickel-chromium steel (8% Ni, 18% Cr)**	
	Nickel-chromium steel (14% Ni, 23% Cr)**	
	Chromium steel (23 to 30% Cr)**	
	Nickel-chromium steel (20% Ni, 25% Cr)**	
	Nickel-chromium-molybdenum steel (12% Ni, 18% Cr, 3% Mo)**	
	Silver	
	Graphite	
	Gold	
	Platinum	

(1) *Trade name: Ni-Resist*
(2) *Trade name: Inconel*
(3) *Trade name: Monel*

Compiled by Robert S. Burpo, Jr., from data obtained from publications of the International Nickel Co., Inc., and Westinghouse Electric Corp.

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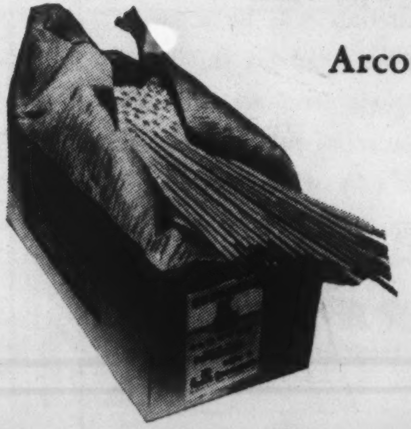

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SHOP NOTES

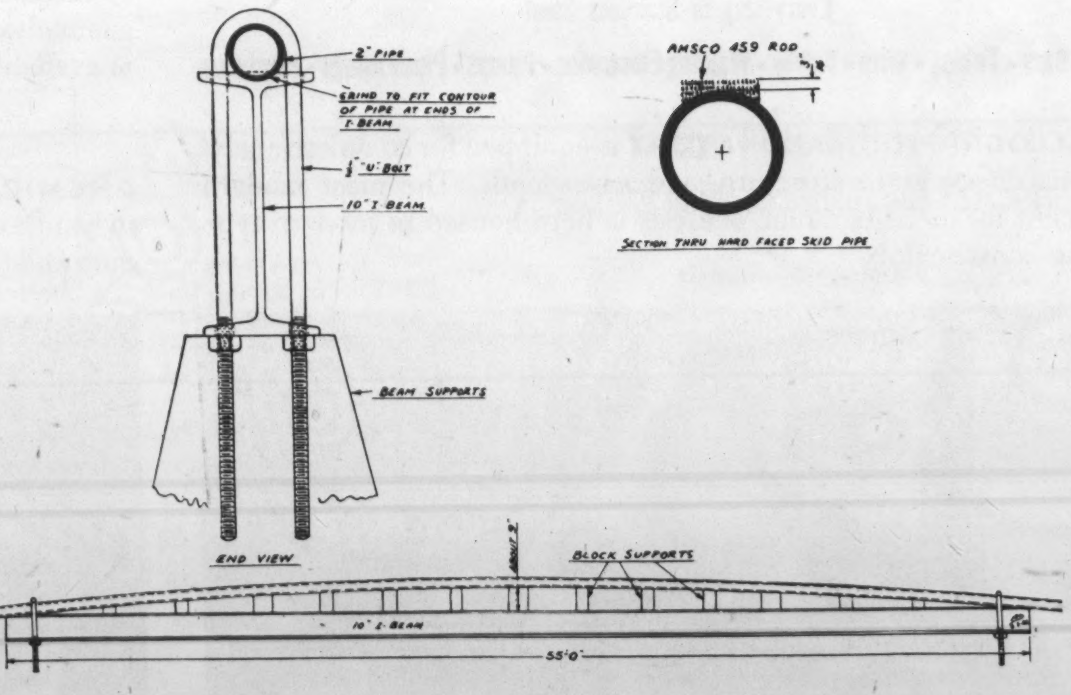
Hard-Surfacing Rolling Mill Skid Pipes

by S. J. Borchers,
American Manganese Steel Div.

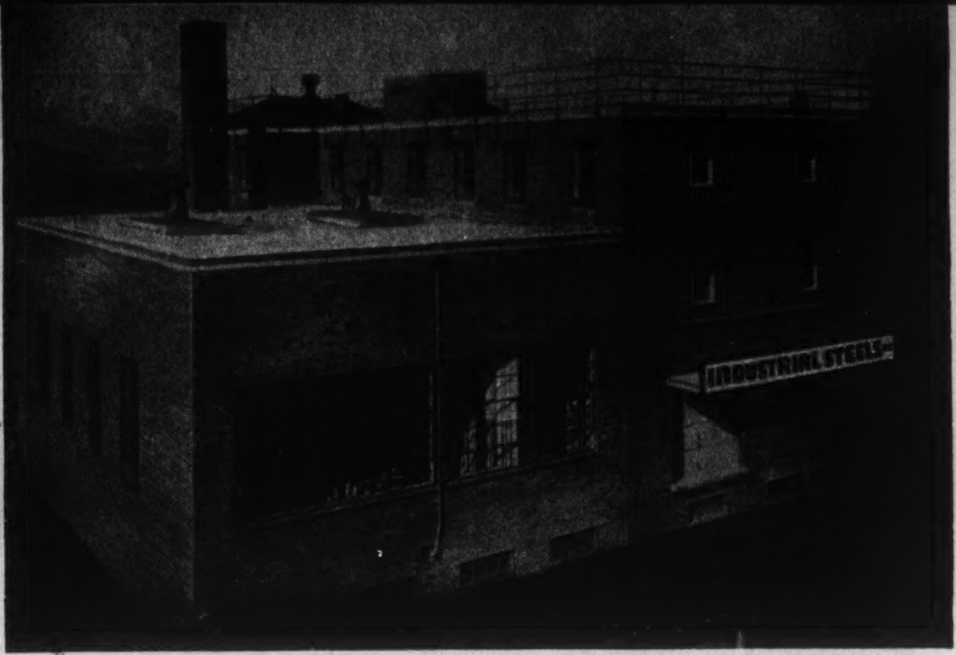
Maintenance of billet-heating furnace skid pipes in rolling mills has always been costly. By the use of hard-surfacing it has been found that the life of the skid pipes can be increased from the usual 6 to 8 weeks to 16 to 18 months.

A typical procedure for hard-surfacing skid pipes by gas welding using a cast hard-surfacing weld rod (Amsco 459) is as follows: To reduce surface checking and to control warpage, prebending of the pipes is recommended. After the skid has been bolted in place on the "I" beam, that portion of the pipe surface to which the weld rod is to be applied should be ground to remove mill scale and rust.

A larger torch tip than for ordinary welding and a neutral oxyacetylene flame to preheat or bring the base metal to a fusion or sweating temperature should be employed. The flame is readjusted to a slight excess of acetylene and the hard-surfacing rod is melted to spread over the sweated surface of the parent metal; the welding rod is added until the proper height, approximately 3/16 in., has been obtained.


2" PIPE
GRIND TO FIT CONTOUR OF PIPE AT ENDS OF I-BEAM
½" "U" BOLT
10" I BEAM
BEAM SUPPORTS
END VIEW
AMSCO 459 ROD
SECTION THRU HARD FACED SKID PIPE
ABOUT 2"
BLOCK SUPPORTS
10" I-BEAM
55'0"

Drawing of a typical rolling mill skid pipe installation for a rail heating furnace.



LABORATORY AND PLANTS of Industrial Steels are housed in this modern brick and glass building. Quarters are spacious, light, airy, and conducive to highest quality production. There is another large Industrial Steels warehouse not shown in this picture.

NEWS ON NITRALLOY!

Boston now has a modern nitriding plant of large-scale production capacity

Industrial Steels, Inc., now licensed to do nitriding for users of Nitralloy, offers New England users of Nitralloy a modern chemical and metallurgical laboratory, a large battery of nitriding furnaces, and the experience of years in the surface-hardening of metals.

Nitralloy's two technical consultants in this area are immediately available for consultation on technical problems of Nitralloy processing and application. Call Industrial at any time to arrange appointment.

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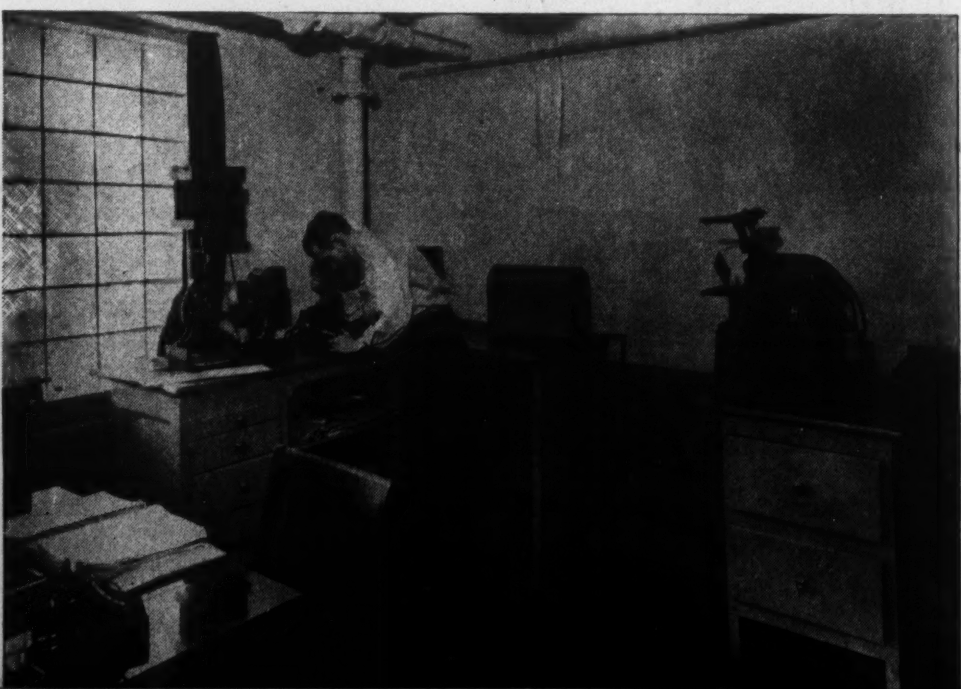


FURNACE ROOM of Industrial's modern Nitriding pl
Picture shows a corner of the furnace room with a retort be
drawn from the pit furnace by the overhead monorail ho

CONTROL BOARD regulates flow of heat and nitriding age
to furnaces. Automatic instruments record temperature
gas analysis on each heat so that complete authenticated rec
is available to customer.

CHEMICAL LABORATORY. Industrial Steels is in a posi
to handle complete chemical analysis for development of pr
dure and for checking final results of all heat treating proces

Solving a Difficult Machining Problem

by Robert Mawson

The Morris Machine & Tool Co., Providence, R. I., recently encountered some unique machining problems in producing governor bodies. This part, shown in the drawing, was made from 1010 angular steel, 3½ by 1½ by 2¾ in.

In the first operation, the bar of steel was turned down for the 1⅜-in. dia. Since the bosses "A" are a portion of the governor body, the part had to be turned large enough to allow for making the bosses in a later operation. The balance of the body was turned in this first operation as well as the ¾-in. hole and the upper face of the part.

The part was then reversed, located on a plug and held in a 3-jaw chuck. With this setting, the flange, the 1-3/32-in. hole and the 1 in.-14 thread hole were machined. On all the surfaces, except "B", 0.0015 in. was left for finish machining operations.

The under-cut surface "B" was next machined down to size, using a universal milling machine head. A stop at each end was used so that the end mill would not machine away the side bosses.

The sides of the flange were then machined in a milling machine. To machine the two side bosses, a 90-deg. angle fixture was attached to the face plate of a lathe. On this fixture a sub-fixture was attached with a pin of the correct diameter to suit the 1-3/32-in. machined hole in the governor body.

The sub-fixture rotated on the pin previously mentioned. To obtain the correct positions when machining the two bosses, an index pin was fitted in a hole in the fixture and through one of two holes in the sub-fixture, 180-deg. apart.

With the combined fixtures located so that the boss was at the correct height for the operation, the bosses, one after the other, were machined to the proper dimensions; then a hole to suit the end of the threaded pin was drilled.

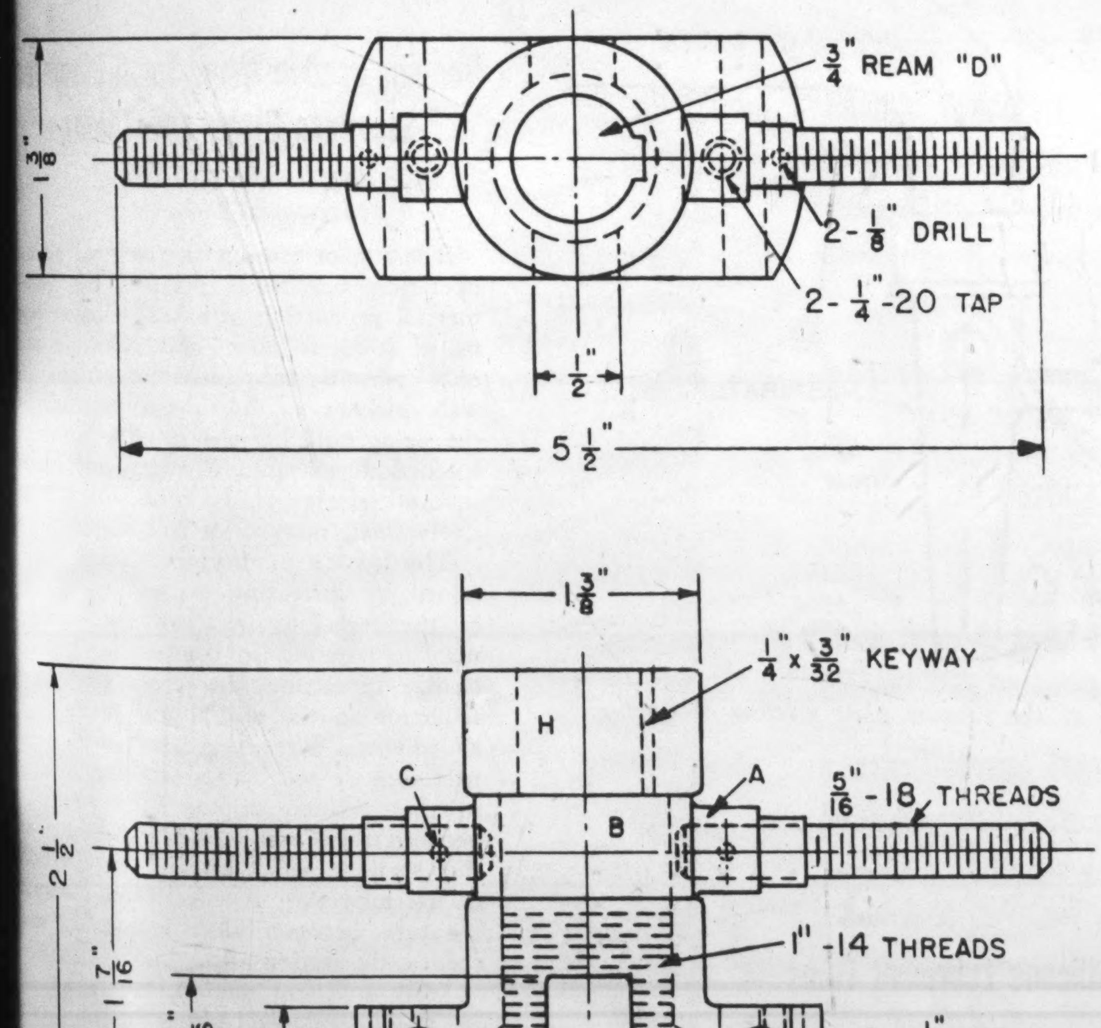
The operation of assembling the threaded pins (made of 1065 steel) was somewhat of a problem owing to the close limits allowed on the drawing: not more than 0.00075 in. with the center of the piece and not more than 0.0015 in. end to end of the pins, vertically and horizontally. To assemble each pin the governor body and threaded pin were heated to 2100 F and copper brazed after the pin had been slid into the hole in the boss. A small hole was then drilled through the boss and the threaded pin; a pin was driven through as shown at "C".

The next operation was the boring and reaming of the ¾-in. hole "D", facing the top end, and machining the upper 1⅜-in. surface to the correct diameter. A special boring fixture, held by two bolts on the face plate of the lathe, was required for this operation.

The next operation was machining the balance of the 1⅜-in. surface. The piece was located on an arbor which fitted the ¾-in. reamed hole, and was held and driven with a 3-jaw chuck. In this setting, not only the outside surface but also the 1-3/32-in. hole was machined to size and the 1 in.-14 thread cut.

The ¼ by 3/32 in. keyway was next machined. This was followed by machining the ½-in. by 11/16-in. deep slots in the base of the piece. For this job the governor body was located on a plug which fit the ¾-in. reamed hole and was held in a 3-jaw chuck placed on a milling machine table. The slots were machined with a ½-in. side milling cutter.

The final operation was machining the holes for the two ¼-in. tap, two ⅛-in. drill, and two ¼-in ream. The jig used for this purpose was made with a plug to fit the 1-3/32-in. hole machined in a previous operation.



Drawing showing details of the governor body.

The working temperature of protecting face plates for oxyacetylene scarfing nozzles varies in cycles from 400 to 1300 F. Under these severe conditions plates of cast iron fail in three weeks. In a recent test Inconel specimens lasted 2½ times as long, and nickel 5 times as long as cast iron.

—From "Process Industries Quarterly"

Vacuum Plate Method for Casting in Porous Molds and Patterns

by Les Wilson,
Calresin Corporation

This vacuum plate method first developed to facilitate making molds on plaster patterns with rubber-like, hot-melt mold materials such as Plastiflex, is also applicable to other casting jobs involving porous molds or porous patterns. It is readily adaptable to plaster mold casting of metals. Thus, it enables the use of inexpensive plaster of Paris molds and patterns with maximum efficiency.

The accompanying sketch shows a simplified version of the vacuum plate. As indicated, the purpose of the vacuum plate is to create a vacuum beneath the porous model or pattern while the casting material

(Continued on page 1506)

is being poured. This vacuum serves to draw off the air, expanded by the heat, from the mold or pattern. This minimizes the possibility of defects due to air bubbles and draws the cast liquid close to the surfaces of the mold or pattern.

Essentially, the vacuum plate set-up consists of a solid slab of a material in which a hole has been drilled. A tube is fitted into this hole and attached to a vacuum pump or aspirator. Marble is the best material for the plate, but satisfactory results can be attained with sheet metals and other materials which will not be affected by the heat of the cast liquid.

This vacuum-casting method can be used for production work by employing larger plates with numerous vacuum holes, all of which can be connected with a single vacuum pump by means of a manifold arrangement.

To explain in more detail the use of the vacuum plate method, here is a typical step-by-step procedure used in making Plastiflex molds:

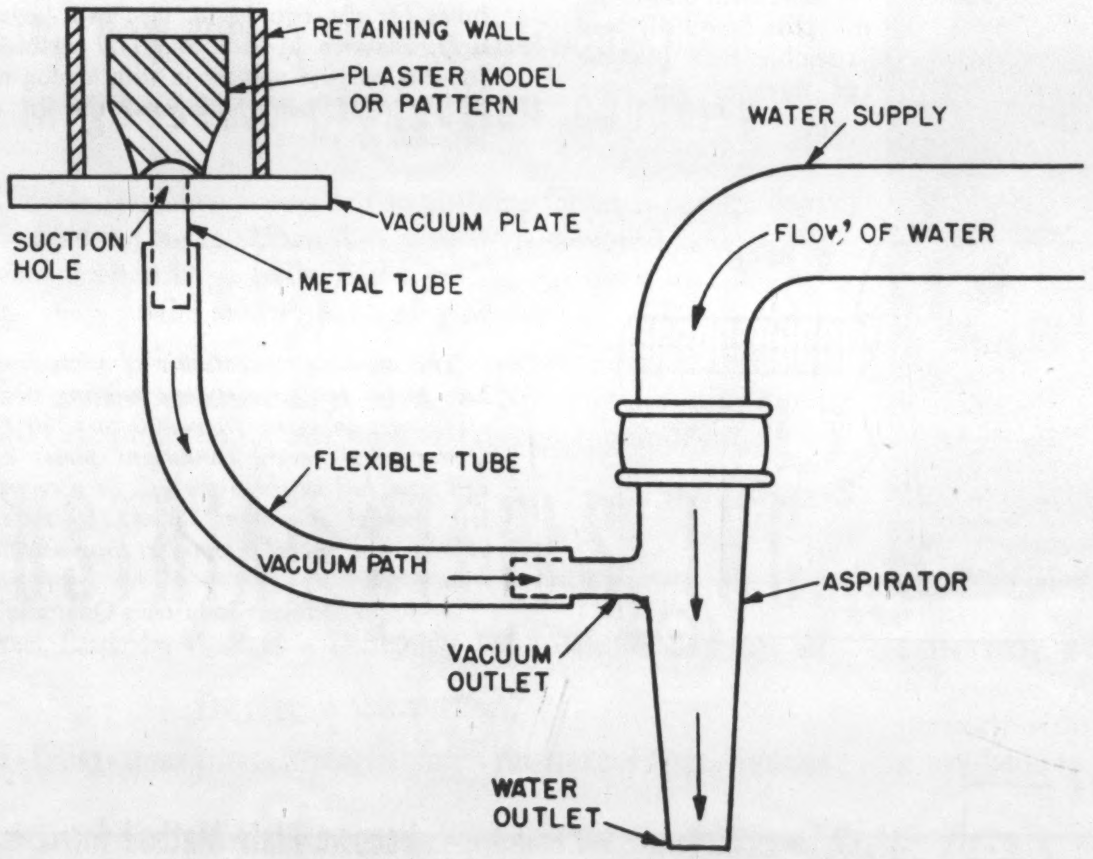
(1) A plaster model or pattern is coated with linseed oil soap and polished with a soft cloth until it has a glossy surface.

(2) A small depression in the base of the pattern is placed directly over the hole in the vacuum plate, and a plaster or metal retaining wall or form is positioned so that it will surround the pattern (see sketch). Multicavity or "gang" molds can be made by resting several patterns on a flat plaster slab over one or more vacuum holes.

(3) Molten Plastiflex (melted at 320 F) is poured between the pattern and the retaining wall on the vacuum plate, so that it will slowly rise and cover the pattern while the vacuum pump is in operation. When the pattern is completely submerged, pouring is stopped and the vacuum pump or aspirator is allowed to continue withdrawing air from the bottom of the pattern until the mold has cooled to almost room temperature.

(4) Water can be poured into the top of the form so as to speed cooling of the mold. Then, after the material has cooled to room temperature, the form is removed from the vacuum plate along with the plaster pattern and mold.

(5) The retaining wall and plaster pattern are respectively separated from the mold.



Schematic sketch showing the essential parts of the vacuum plate method of casting.

A Method for Removing Silicone Lubricant Films

The many unique advantages to be gained through use of silicone lubricant films (such as DC stopcock grease and DC high vacuum grease) have been reluctantly given up by some laboratories because of the difficulty in removing from glass the non-wetting film formed by these silicone lubricants. The best cleaning methods previously developed involved use of caustic solutions which had to be carefully watched to avoid etching the glass. A hydrocarbon solvent has been found which quickly and efficiently removes silicone films from glassware.

This discovery was reported by G. Constabaris of the University of British Columbia. He found that silicone grease could be easily removed from laboratory glassware by decahydronaphthalene, sold under the trade name of Decalin.

The effectiveness of this solvent for removing silicone lubricants has been verified. On the basis of these tests the following procedure is recommended:

Soak glassware for about 2 hr. in warm Decalin. Rinse thoroughly with acetone and dry with filtered air. Repeat, if necessary. In most cases the same Decalin bath can be used several times.

These laboratory tests also indicated that only a very thin film of silicone lubricants is necessary to provide effective lubrication and that judicious use of the greases and frequent cleaning should prevent surface contamination.

—From "The Eberbach Announcer."

Since iron is very soluble in molten silica, an ingredient of the aluminum-silicon alloys, our aluminum foundries are changing over to the refractory or graphite type crucible. It is reasonable to expect that this change will minimize or eliminate our troubles with iron pick-up in the aluminum alloys. (Anthony Cristello, Eclipse-Pioneer Div., Bendix Aviation Corp.)

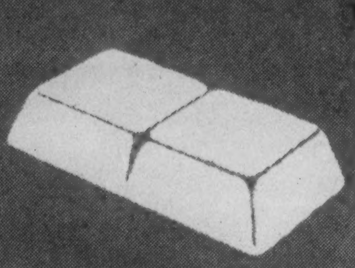
Tension Used in Sizing Small Diameter Seamless Pipes and Tubing

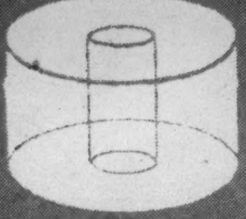
by Stevenson Findlater,
National Tube Co.

The use of tension in the final sizing operation has made possible the commercial production of small diameter hot rolled seamless pipe. This principle not only permits substantial reductions in wall thickness of the tube to be made in the sizing mill, but also provides a means for making exceptionally large reductions in the diameter of the tube with a relatively small number of roll stands.

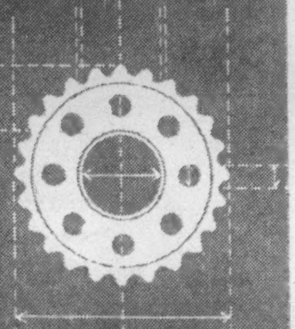
The tension in the tube section is obtained by increasing the relative speeds of the rolls in successive stands more than is required to compensate for the change in section area produced by the reduction in the several roll passes. The added speed differential between the rolls in successive roll stands produces tension in that portion of the tube which is between these stands. The magnitude of this tension, which acts in the direction of the tube axis, is sufficient to elongate the tube between successive stands, and reduces the section area.

With sufficient tension, the reductions in wall developed between stands can exceed the thickening produced by the compressive forces in the roll pass; thus, it is possible to produce finished tubes of lighter wall than the entering shell. When the wall thickness of the tube is reduced by this means, large diameter reduction can be made in the roll stands without the usual tendency toward noncircular inside contour.





Edited by H. R. Clauser
Associate Editor,
Materials & Methods



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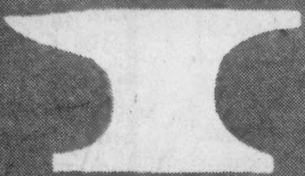

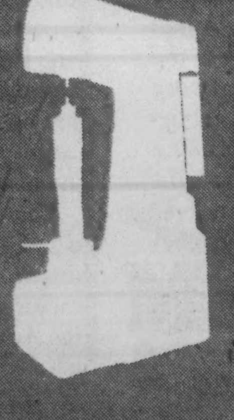

MATERIALS & METHODS DIGEST

A selection of outstanding articles on engineering materials and processing methods in the metal-working industries.

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METALS and ALLOYS

Engineering properties and applications of carbon, alloy and stainless steels, irons and nonferrous metals and alloys. Selection and evaluation of metallic materials for engineering service. New alloys and modifications.

High-Coercive Magnet Alloy

Condensed from "Engineers' Digest"

Magnico is an alloy containing 12% cobalt, 6% copper, 10% aluminum and 18% nickel. It shows an increase of 10% over Alnico, a popular magnet alloy, in residual induction. The coercive force is unchanged over Alnico at 520 Oersted. The magnetic energy is increased by 20% by the application of a thermo-magnetic treatment. The idea was to find a better alloy for use in magnetos.

Tabulated properties of magnetic materials experimented with follows:

	3% Cr-steel	15% Co-steel	30% Co-steel	Alnico 25% Ni 15% Al	Alnico 34% Ni 14% Al 1% Si	Magnico magnetically treated, 24% Co
Coercive force Oersted	60	170	220	550	800	580
Residual induction Gauss	9,000	8,000	9,000	5,500	4,200	13,300
Magnetic energy erg per cu.cm.	9,000	22,000	35,000	50,000	55,000	200,000
Relative weight per unit of energy	22	8·0	5·7	4·0	3·7	1·0
Optimum ratio length/cross section	12	4	3	1·3	0·9	3·0

As to residual induction, coercive force and magnetic energy, Magnico can be made to exceed another alloy (Alni—27% nickel, 15% aluminum), by 50%, which offers considerable advantages for magnetos, electric generators, etc. With Magnico not only the true residual induction in the closed magnetic circuit is increased, but the induction is also increased under conditions such as are obtained in magnetic circuits encountered in actual practice. Its magnetic energy is found to be four times that of Alni and 22 times that of ordinary chromium steel.

Prior to the development of Magnico, the employment of the iron-nickel-aluminum alloy Alni, containing 23 to 30% nickel, 12 to 16% aluminum and 3 to 5% cobalt as material for permanent magnets had led to the almost complete elimination of the cobalt steels.

The possibility of using this alloy for the high coercive force of 500-600 Oersted in several cases is precluded by its low residual induction of 5000-6000 Gauss. Attempts were therefore made to find an alloy which combines a high coercive force with high residual induction. The use of chromium, tungsten, molybdenum, vanadium, niobium, copper and silicon in the Alni alloy did not lead to the desired result. The only element giving the right influence was, therefore, cobalt.

It has been found that cobalt increases coercive force without impairing the residual induction, due to the fact that cobalt is the only element which increases the magnetic saturation of iron and, by entering into the crystal lattice of iron, acts to decrease the lattice parameter, thereby causing a sharp increase in internal tension of the submicroscopic crystalline lattice whenever the lattice, for some reason, undergoes deformation. (A. S. Zaimovski & L. M. Lvov. *Engineers' Digest* (Am.), Vol. 3, Aug. 1946, pp. 389-391.)

Die Steels for Hot Work

Condensed from "Metallurgia"

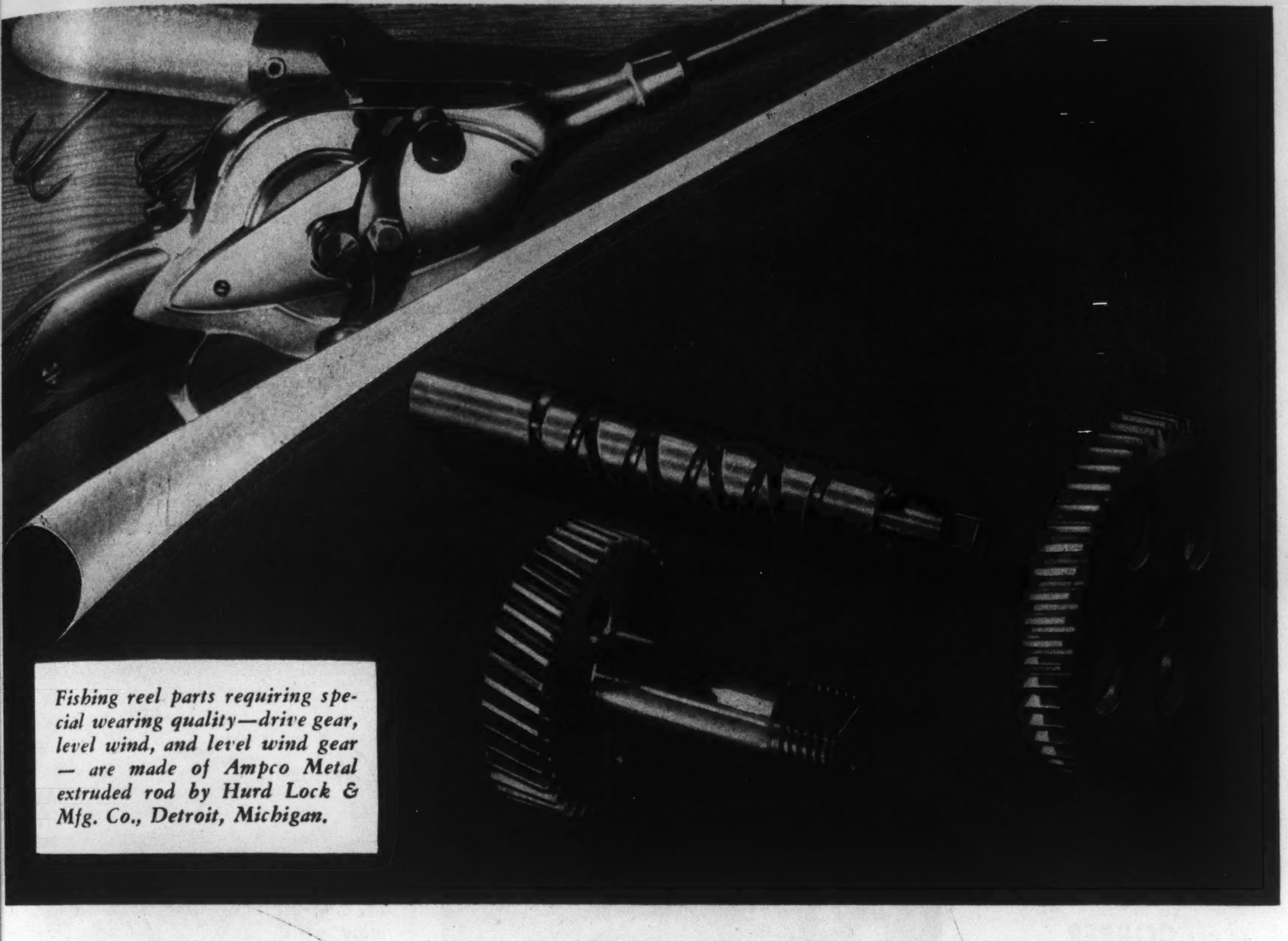
An ambitious laboratory program in Germany investigated the effect of additions up to 4.9% molybdenum, 1.2% vanadium and 11.7% tungsten, individually and together, to a base composition containing 0.22 to 0.42% carbon and 1.3 to 2.1% chromium. Their work was mainly concerned with the properties of the steels at 930 to 1110 F, and with the ability of the steels to withstand abrupt changes in temperature. The results indicate that it is the tungsten content which is responsible for a high resistance to fire checking.

Neither vanadium nor molybdenum can be considered as a satisfactory substitute in this respect. In regard to strength at elevated temperatures, the most efficacious element is vanadium while tungsten is the least. Considerable deterioration in the notched bar impact strength is caused by increasing vanadium. The adverse influence of tungsten on thermal conductivity is smaller than that of either vanadium or molybdenum. This fact compensates to a certain extent for the diminution in thermal conductivity incurred with the use of high tungsten percentages.

Russian efforts to eliminate tungsten appear to have been directed mainly towards the employment of chromium-manganese-silicon materials, although an 8% tungsten and an 8% chromium-3% tungsten steel was much used at one time. The main reliance was not on laboratory tests but on determining the service life of hot work punches and dies under actual operating conditions. The compositions tested were: (1) 0.46 C, 0.45 Mn, 3.1 Si, 8.18% Cr; (2) 0.54 C, 1.39 Mn, 0.38 Si, 0.72 Cr, 0.28% Mo; (3) 0.35 C, 1.05 Mn, 1.4 Si, 1.3% Cr; and (4) 0.64 C, 0.7 Mn, 0.3% Si.

It was concluded that the tool life was little dependent upon the initial hardnes and impact strength. However, Steel 3 at a Brinell hardness of 418 to 444 had a much lower life than the same steel at 286 to 302. It is believed that good thermal conductivity and a high Ac3 point are important. The required mechanical strength can be obtained by adding 1 to 1.5% chromium while the required high critical can be achieved with 1.0 to 1.5% silicon. Large amounts of tungsten are therefore not always to be recommended.

The carbon content should be kept at 0.3 to 0.4% as higher carbon contents in combination with the chromium and silicon impair the thermal conductivity and depress the Ac3 point. Material similar to Steel 3



Fishing reel parts requiring special wearing quality—drive gear, level wind, and level wind gear — are made of Ampco Metal extruded rod by Hurd Lock & Mfg. Co., Detroit, Michigan.

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1 Production savings of extruded stock

- ✓ Sizes parallel requirements—reduces waste.
- ✓ Reduces machining time and costs.
- ✓ Compact structure cuts rejections.

2 Performance advantages of Ampco Metal

- ✓ Higher fatigue and impact strength.
- ✓ Higher compressive strength.
- ✓ Resistance to corrosion.
- ✓ Light weight.

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Ampco Metal is an aluminum-bronze type alloy with superior wearing qualities ideal for parts subject to impact and fatigue, compression, and corrosion.

Ampco's extrusion press is one of the largest in the middle-west and one of the few in the world devoted to the extrusion of aluminum bronze. Extruded Ampco rods are produced and stocked in two grades of Ampco Metal and two grades of Ampcoloy bronze — ask your nearby Ampco engineer to help you specify the proper grade for your requirements.

Write for Bulletin 64A.

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is recommended for hot work punches. (D. W. Rudorff. *Metallurgia*, Vol. 34, Aug. 1946, pp. 189-193.)

Aluminum Casting Alloy

Condensed from "American Foundryman"

Methods of recovery of aëroplane aluminum scrap have made available an excellent source of material for the production of general-purpose aluminum alloys. An alloy has been developed having good casting and mechanical properties without resort to solution heat treatment. These properties can be enhanced by heat treatment if necessary. Basic typical composition is 3% copper and 5% silicon. The properties are substantially the same as those of an alloy containing 1.3% copper, 0.5% magnesium, and 5% silicon (alloy 1), and of an alloy with 0.3% magnesium and 7% silicon (alloy 2).

Test specimens were cast at 1260 to 1280 F into green-sand molds. In the as-cast condition, the yield strength was 14,000 psi.; tensile strength, 26,500 psi.; elongation in 2 in., 3.3%; and Brinell hardness with 500-kg. load, 61. The tensile strength is as high as that of No. 12 alloy (8% copper), but the elongation is much greater.

In the solution heat-treated-and-aged state, this alloy had a yield strength of 18,200 psi.; tensile strength of 33,200 psi.; elongation of 4.2%; and Brinell hardness of 69. The alloy thus surpasses No. 12 alloy, which cannot be markedly improved by such treatment. The only marked difference in comparison with alloys 1 and 2 was in the low yield strength.

In the stress-relieved condition, the yield strength of the alloy was 16,100 psi.; tensile strength, 28,900 psi.; elongation, 2.8%; and Brinell hardness, 64. The ductility is greater than in either alloys 1 and 2, but the yield strength is again lower.

Permanent-mold castings of the alloy were made using the same melting and casting technique. In the as-cast condition, the yield strength was 14,800 psi.; tensile strength, 30,600 psi.; elongation, 3.2%; and Brinell hardness, 69. Solution heat treated and aged, the alloy had a yield strength of 18,200 psi.; tensile strength of 38,900 psi.; elongation of 6.6%; and Brinell hardness of 76. It had lower tensile and yield strengths than alloys 1 and 2, but higher ductility. In the stress-relieved condition, the tensile strength was 18,600 psi.; tensile strength, 34,000 psi.; elongation, 2.5%; and Brinell hardness, 73. The tensile strength and ductility exceed those of alloy 1, with the yield strength again lower.

Results of fatigue tests of solution-heat-treated-and-aged green-sand castings indicate that the alloy has unusually high fatigue strength.

Results of tests on specimens containing up to 0.16% magnesium showed a quite noticeable increase in yield strength, with a somewhat lesser increase in tensile strength, while the ductility decreased somewhat. In applications requiring higher impact value, the magnesium should be kept to a minimum. For applications requiring

(Continued on page 1516)

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...will cause no change in chemical analysis because there are no elements in the compound that will cause contamination.

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a higher yield strength, the alloy should contain some magnesium.

The composition of the alloy is 2.3 to 3.5% copper, 4.5 to 6.0% silicon, 0.15% maximum magnesium, 1.0% maximum iron, 0.2% maximum nickel, 0.5% maximum manganese, 0.7% maximum zinc, 0.5% maximum special-purpose elements, 0.3% maximum other elements, and remainder aluminum. (O. Tichy. *Am. Foundryman*, Vol. 10, Sept. 1946, pp. 74-80.)

Platinum-Iridium Alloys

Condensed from "Metallurgia"

The process of diffusion in platinum-iridium alloys was studied with alloys containing 10, 25, 35 and 50% iridium. They were prepared from their components mixed in the form of powder. The process was studied at temperatures of 2372, 2552 and 2732 F over periods up to 40 hr. It was found that the diffusion process takes place very intensively. In all the alloys considered, a solid solution was present after only 10 hr. heating at 2372 F.

The formation of a homogeneous solid solution was indicated by the appearance of a maximum on the curves for specific electrical resistance and the time agreed with the evidence obtained from microphotographs and X-ray analysis. The results of X-ray analysis indicate that the alloys studied obey Vegard's law—there is a linear relationship between the lattice parameters and the concentration.

From the X-ray data the conclusion is drawn that the rate of diffusion of iridium into platinum is lower than that of platinum into iridium. A similar effect is known to occur with many precious metals, and it finds expression in the rule: the higher the melting point, the lower the diffusion rate.

The formation of solid solutions at comparatively low temperatures and in relatively short periods of time is of practical importance from the point of view of the possibility of employing the method of powder metallurgy for the technical preparation of platinum-iridium alloys. It is possible, even at 2372 F, to obtain a completely homogeneous alloy of platinum with 25% iridium, while in the usual metallurgical method it is necessary to work at a temperature above (3452 F) which presents certain well-known difficulties.

If, however, one manages to overcome these temperature and furnace difficulties in connection with the 25% iridium alloy, one meets still greater difficulties in attempting to make alloys containing, say 50% iridium, by metallurgical means. By applying the metallo-ceramic method, one may simplify the operations, raise the purity and cut down wastage. In addition to all this, the method could be used for obtaining directly—avoiding casting, forging, rolling and other operations—articles with simple and most serviceable forms and dimensions. (O. E. Zvyagintsev, A. G. Rakhshtadt & M. A. Vladimirova. *Metallurgia*, Vol. 34, Aug. 1946, pp. 195-198; translation from *J. Applied Chemistry* (U.S.S.R.), Vol 17, 1944, pp. 22-30.)

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"STAR MAX"	Carpenter Steel Co.
"MOLITE M-1"	Columbia Tool Steel Co.
"REX T-MO"	Crucible Steel Co. of America
"DI-MOL"	Henry Disston & Sons, Inc.
"HI-MO"	Firth-Sterling Steel Co.
"REX T-MO"	Halcomb Steel Co.
"MOGUL"	Jessop Steel Company
"TATMO"	Latrobe Electric Steel Co.
"MIDMAX"	The Midvale Co.
	St. Lawrence Alloys, Inc.
"S. T. M."	Simonds Saw & Steel Co.
"MO-TUNG"	Universal-Cyclops Steel Corp.
"8-N-2"	Vanadium-Alloys Steel Co.
"VUL-MO"	Vulcan Crucible Steel Co.

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NONMETALLIC MATERIALS

Design-uses of plastics, plywood, fibre, glass, rubber, ceramics, etc. as engineering materials. Composite metal-nonmetal combinations. New forms of nonmetallic materials.

Heat Sealing Thermoplastics

Condensed from "Modern Plastics"

The only real way in which electronics has affected sealing methods is by furnishing a source of energy that actually does not exist as heat until the energy is inside a material. Heat affects the surface of a thermoplastic in a way similar to a solvent or a cement. It prepares the surface to be sealed so that if pressure is then applied a bond results.

Among the examples of items of thermoplastic materials that can be sealed by high frequency energy are belts and buttonholes, ping pong balls, beach balls, surf boards, wading pools, solar stills, water bags, baby pants, bibs and dress shields.

Electronic sealing is heat sealing. But because the heat is confined and controlled, more uniform seals can be made. The strength of the seal is not weakened by extrusion of the hot material around the electrode bars. Moreover, no solvents are added to the material to be absorbed by it, and no glues are present to deteriorate.

All thermoplastics do not heat-seal by the electronic heating method. Polystyrene, for example, because of its electrical properties, will not get enough heat to seal. There are two distinct methods of using such power. If you can adapt a fixture or die and arrange to hold the pieces properly so as to obtain "kick press" production of your product, you will benefit from long run production of this type. The output of the electronic generator must be great enough to heat the total area desired in one press operation. Thick materials can be sealed.

Where intricate shapes or patterns are required, or where quantities are small and changed often, the scanning technique of a sewing machine should be used. No further costs are involved, and almost any seam can be made. If speed is not important a seal of any length can be made on a sewing machine. The same power is used regardless of the work being done.

The Singer electric bonding machine seals by means of a small bar sealer that goes up and down rapidly, each pressure stroke overlapping the previous one. While the bar electrode is up, an intermittent drive wheel pulls the material forward. The resultant seal is a continuous bond. Speed is controlled by two adjustment knobs. Frequency of current applied to bars is about 60 megacycles.

A second machine manufactured by the Union Special Machine Co. is a roller type unit. The unit has been designed so that if the material varies in thickness from two 4-mil sheets to ten 4-mil sheets, the temperature of the seam will remain constant and the seam will be uniform. The same rollers that feed the material are used for sealing, and are continuous in movement.

It is possible to seal more than one seam in one shot, provided the seams are made simultaneously. Thus, in one machine three pieces of a pattern are inserted in the fixture and the top element, which serves as a common electrode for both sides, is closed down. A flat plate holds the side pieces in contact with the outer electrodes, which are brought into place as the flat springs lift the center piece so that a turned up edge seal is made. With such techniques bathing caps are often made. (Wiley D. Wenger. *Mod. Plastics*, Vol. 23, July 1946, pp. 135-139.)

Postwar Aluminum

Condensed from "Mining and Metallurgy"

Nature made aluminum light and research made it strong. Eight years before the war the Aluminum Co. of America produced an improved heat-treatable alloy called 24S, which became the basic material for airplanes in World War II. Then came alloy 75S, which is different from duralumin in that zinc and magnesium are the hardening elements instead of copper, magnesium and silicon.

This alloy has a yield strength of over twice that of mild steel, is one of the strongest aluminum alloys yet available, and is not subject to stress-corrosion cracking. Its development came too late for wartime use on a large scale, but it was used in the upper wing skin of the B-29 bomber. The increased strength resulted in a weight saving of 400 lb. per airplane. Use of this alloy for keys is a new post-war application. Being light in weight, these keys save wear on pockets and can be finished in attractive colors.

An outstanding war contribution was Alclad sheet products. Thus, Alclad 24S-T sheet, a duplex product, has a heat-treated aluminum alloy core for strength and thin surface layers of pure aluminum for corrosion protection. It is anodic to the core, hence gives electrochemical protection. This product was developed before the war, but Alclad 75S and Alclad 14S products came out during the war.

Alclad 3S sheet is used for Mason jar caps and tea kettles, and has been used for aviation gasoline tanks and for water and gasoline tanks on PT boats. It has high resistance to perforation by corrosion. Aluminum alloys are also used for bearing materials, particularly for Diesel engines.

The alloy 63S is corrosion resistant and takes a clear bright Alumilite anodic finish with a minimum of streaking and discoloration. It is intended for windows, store fronts, escalators and other architecture.

Another alloy is for roofing sheet. A casting alloy, A 100, for rotor use, is suitable for low-resistance electric motors. Aluminum alloys will find increasing application in the manufacture and handling of organic and inorganic chemicals, textiles, petroleum products, rubber, paper, soap, paint and explosives.

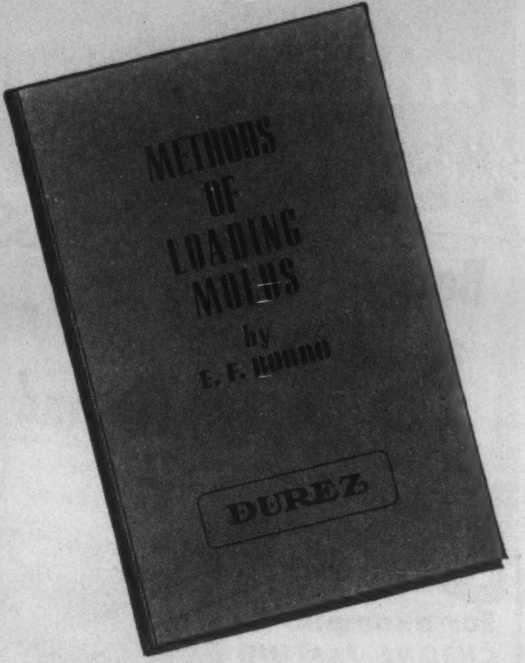
It is practical to make permanent mold castings weighing 100 lb. or more, thus providing lower costs for quantity production with metal dies. These possess better mechanical properties than sand castings, with closer dimensional tolerances. They can be used in the automotive industry for transmission cases, engine blocks and rear axle housings.

Methods for mass production of press forgings and impact extrusions made for tremendous savings in time and money during the war. Larger and longer extrusions are now available. A stepped extrusion is available for wing spar construction. Fusion welding of aluminum alloys is possible without flux and at excellent speed, done with a tungsten arc in an argon atmosphere.

Spot welding can be done in thicknesses up to 3.16 in. Also, an entirely new brazing art has been developed, such as for fabrication of aircraft heat exchangers, oil coolers, radiators and intercoolers. (F. Keller. *Mining & Metallurgy*, Vol. 27, Aug. 1946, pp. 431-433.)

ENGINEERING DATA ON PLASTICS

7. METHODS OF LOADING MOLDS



An accurately measured charge of molding material in the mold cavity is a deciding factor in producing satisfactory parts economically. Test yourself. Can you answer the following questions on this subject?

What is the result of too small a charge? Too large a charge?

Which method of loading is best for high-impact canvas-filled material? For multiple-cavity molds?

What are telescoping loaders?

What is the basic fault of the multiple volumetric method of loading?

These questions and many others are fully answered in a new four-page booklet titled "Methods of Loading Molds." This free authoritative folder contains a compilation of data recently collected by Durez engineers . . . and includes helpful charts similar to those shown below. Write: Durez Plastics & Chemicals, Inc., 912 Walck Road, North Tonawanda, New York.

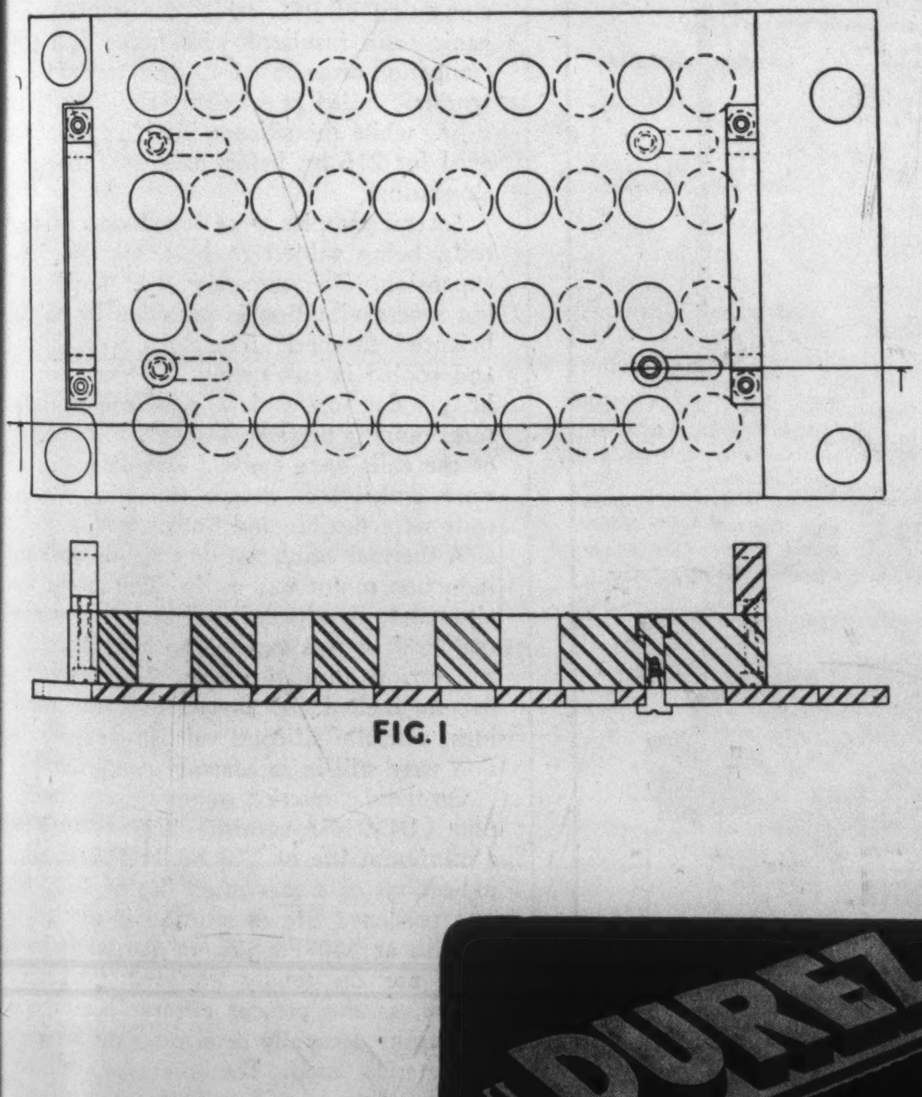


FIG. I

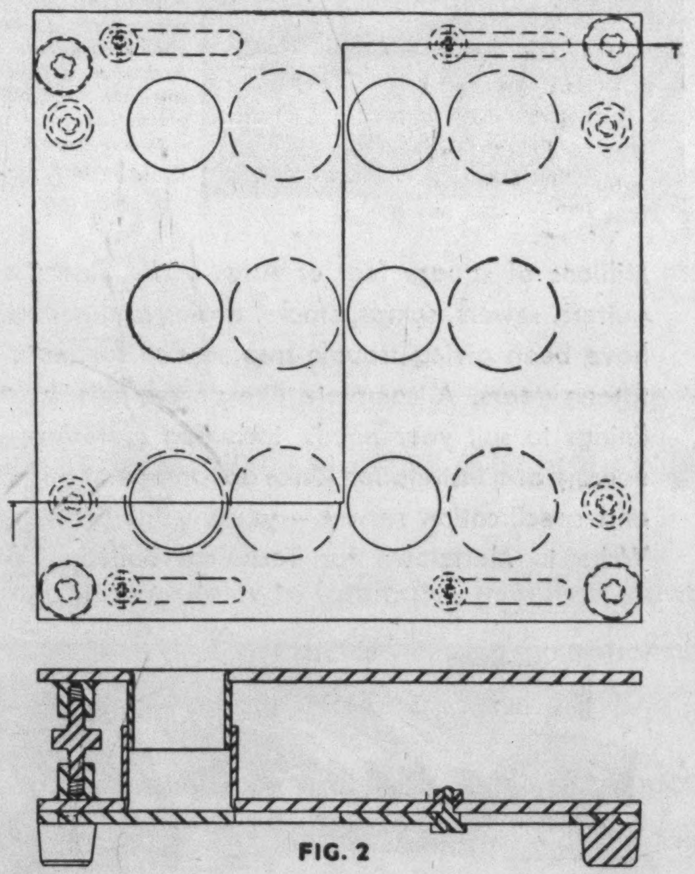


FIG. 2

DUREZ

PHENOLIC RESINS

- MOLDING COMPOUNDS
- INDUSTRIAL RESINS
- OIL SOLUBLE RESINS

PLASTICS THAT FIT THE JOB

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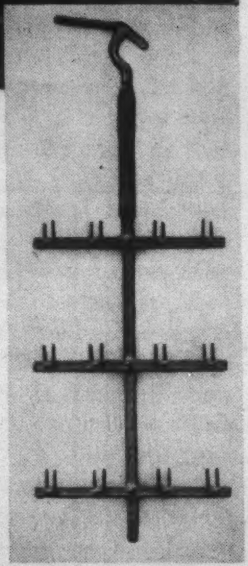
And in this acid tank for glass etching, the steel shell is protected against hydrofluoric acid by lining with Atlas NEOBON synthetic rubber, applied with brush and built up to required thickness.



Rack type ELECTRODE for plating small articles. Current passes from top hook to small suspension hooks. Shaft and arms are covered with NEOBON to protect them against plating solutions.

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Silicones

Condensed from "Southern Machinery & Metals"

The advent of silicone materials, promising much greater thermal endurance for insulation, is of vital interest to electrical engineers. It may be used by designers of electrical apparatus in three ways: To reduce size and weight of some apparatus through increase in operating temperature; to permit operation in a high ambient temperature; to obtain increased insulation service life or reliability where it is desired to maintain conventional size, weight and temperature.

Silicones are natural complements to glass, mica, and asbestos in bonding, filling voids, and excluding moisture. In evaluating silicones, the basic materials were subjected to laboratory tests such as used for testing organic varnishes and bonds. The most common test is for flexing life of panels, corresponding to the ASTM heat endurance test for varnishes, except that elevated temperatures are used.

The results of such tests for a silicone resin and one of the better organic synthetic resin (phenolic-alkyd) varnishes shows a tremendous advantage for silicones. A comparison of a wire enameled with an oleoresinous varnish, a synthetic organic resin enamel, and one of the silicone insulating varnishes shows the same advantage for silicone.

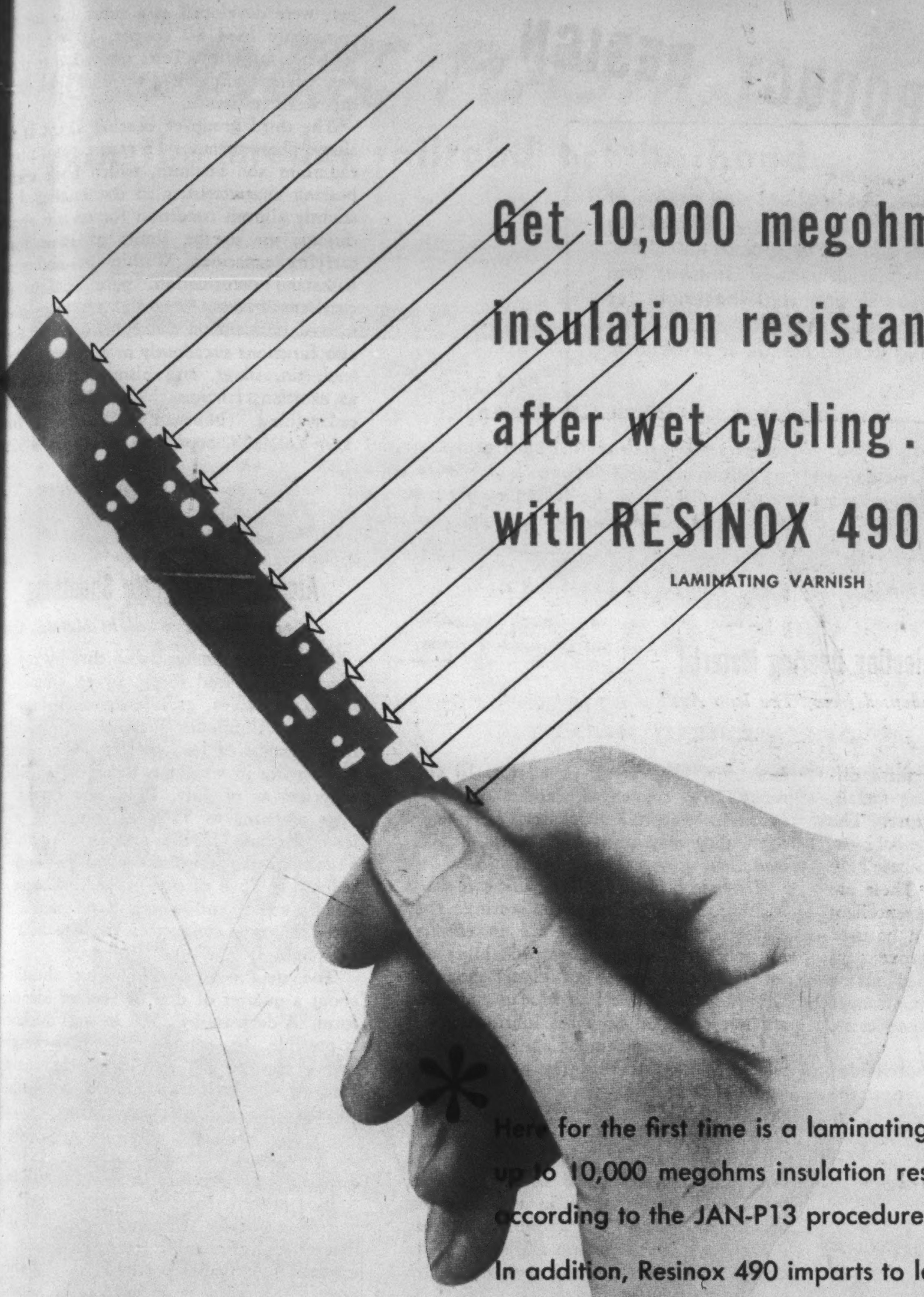
At 300 F the silicon enameled wire was aged for 6900 hr. before it failed at an elongation of 9%, while the synthetic organic resin insulated wire failed at a 9% elongation after only 240 hr. At 390 F the synthetic failed at an elongation of 3% in 2 hr., while the silicone-insulated wire was aged for 216 hr. before failure at the same elongation.

Several samples were tested on armature coils, being subject to heat, vibration and expansion. The armature does not rotate, but severe vibration is provided by an unbalanced flywheel. The coils were heated and cooled intermittently. The test ran 16 hr. per day for 36 days, with coil temperatures ranging between 410 and 450 F. Many of the coils were cracked and damaged; all were embrittled, except that the silicone coils were flexible and undamaged.

A thermal aging test of a totally enclosed induction motor was made. The motor was alternately overloaded and reduced to normal load; it was exposed to high humidity and various insulation tests. The rotor conductors melted and flowed over the windings, but the silicone varnish and insulation were still in satisfactory condition.

On the d.c. traction motor silicone insulation (DC-990-A-varnish) appears to have a minimum life of 350 hr. at 550 F, with indications of a maximum life of 1400 hr. The predicted life of silicone insulation is 380 hr. at 550 F. Silicone materials have more use on totally enclosed fan-cooled motors, as the present allowable temperature limits generally determine the amount of materials used. For this type, silicone materials have been found advantageous.

The moisture resistance of silicone coils is outstanding, and there may be a field for its use where no advantage is taken of its high thermal stability. (Graham Lee Moses. *Southern Machinery & Metals*, Vol. 2, Aug. 1946, pp. 12-15, 24-26.)



Get 10,000 megohms insulation resistance after wet cycling . . . with RESINOX 490*

LAMINATING VARNISH

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In addition, Resinox 490 imparts to laminates excellent power factor, dielectric constant, and loss factor . . . also exceptionally good hot punching characteristics.

If you manufacture or use these materials, why not specify Resinox 490 as the laminating varnish . . . and take advantage of extra, important qualities. For complete data on this application or on other post-forming or general-purpose laminating varnishes . . . simply address: MONSANTO CHEMICAL COMPANY, Plastics Division, Springfield 2, Massachusetts. In Canada: Monsanto Ltd., Montreal, Toronto, Vancouver.

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GENERAL PRODUCT DESIGN

Selection, applications and design of parts made by various fabricating methods or made of special materials. Properties and uses of finishes and coatings. Design and materials for specific products or fields. General engineering design trends or principles.

Selecting Bearing Material

Condensed from "The Iron Age"

It is recognized that there are three different types of nonferrous bearing metals, varying in their physical structure. The first group consists of the lead-base babbitts, the tin-base babbitts, the cadmium-base babbitts and the zinc-base babbitts. These are of relatively soft material, have excellent antiseizure characteristics, and can be used at high sliding speeds. To improve load carrying capacity they must be supported by a bearing shell made of a stronger material such as steel, or, in some cases, bronze.

The lead-base group may be subdivided further into the lead-antimony series, the lead-antimony-tin series and the lead-calcium series of alloys, each series having its own bearing characteristics and field of application. The lead-antimony alloys contain up to a maximum of 18% antimony, which acts as a hardener for the lead. The lead-antimony-tin series of alloys is stronger and suitable for moderate to high speeds, moderate loads, and can be used at higher operating temperatures. Very good frictional properties, reasonably good corrosion resistance and low price have established a wide field of application for the lead-antimony-tin babbitts.

The lead-calcium or lead-alkali alloys, containing about 97.5% lead, are the precipitation-hardening type and retain hardness better at elevated temperatures, resist impact better, but have lower corrosion resistance. These alloys have high coefficients of expansion and high rates of wear. Other alkali or alkaline earth metals may be substituted for the calcium. This type is used where loads are light to moderate and speeds are low.

The tin-base babbitts contain tin, copper and antimony with cadmium and nickel sometimes added to improve their properties. These babbitts range in composition from 92 tin, 4 antimony, 4% copper with about 20 Brinell hardness, to 79 tin, 12 antimony, 7% copper or 80 tin, 10 antimony, 10% copper with about 29 Brinell hardness. For the purpose of reducing costs, they may contain as much as 30% lead.

Tin-base babbitts work against soft shafts with little tendency towards scoring. They allow low clearance, an aid to effective lubrication; are high in embeddability and conformability; have low elastic modulus; bond reasonably well to bronze and steel; are not corroded by most lubricating oils at operating temperatures; and are properly wetted by the lubricant. The only drawback is the low melting point of tin and the rapid falling off of strength as the melting point is approached.

Cadmium-base alloys contain 97 to 99% cadmium plus nickel and silver or copper. If silver is not present in the alloy, its performance is not satisfactory as a bearing material. A cadmium-base alloy containing about 1.35% nickel has a tensile strength of 16,400 psi., and elongation of 19%, a reduction of area of 43%, and is less brittle than the tin-base babbitts. This alloy is used for conditions of high stress and high temperature.

The second general group of bearings is the copper-lead alloys and the copper-tin-lead alloys containing up to 30% lead. In general, they are used for severe service where babbitts will fail. The 30 to 35% leaded copper alloys have excellent bearing properties. However, the strength is low and the alloys are subject to failure by fatigue cracking. The higher the lead content of these binary alloys the lower is the fatigue strength and the higher the antifrictional characteristics. The addition of tin increases strength and reduces the tendency towards fatigue cracking.

Two new bearing alloys, containing 8 nickel, 1 antimony, 1 zinc, 10% lead, balance copper, and 8 nickel, 2 tin, 1 antimony, 1 zinc, 10% lead, balance copper, were developed as a substitute for the commonly used 80 copper, 10 tin, 10% lead bearing alloy. Tests showed that the new bearing alloys had three to four times the wear resistance.

The third group of bearing alloys is the single phase metals such as tin, lead, silver, cadmium and bismuth, which have useful bearing characteristics in the unalloyed or slightly alloyed condition for certain applications, up to the limits of their load-carrying capacities. Within its ability to withstand deformation, pure lead is an excellent bearing material. A very thin film of pure tin on a supporting steel back also functions excellently as a bearing. Pure lead, tin, silver, and bismuth have good to excellent friction characteristics, in the order listed. (Norman E. Woldman. *Iron Age*, Vol. 158, Sept. 5, 1946, pp. 54-57.)

Aluminum for Cable Sheathing

Condensed from "Light Metals"

It has been demonstrated that by replacing the usual lead sheath by an aluminum sheath in cables, great economies may be effected. Aluminum sheaths are one-third the thickness of lead sheaths. The percentage saving in weight is about 90%, while at prices as of July, 1946, the saving in costs amounts to 55% as compared with lead. Because of the greater strength of aluminum the thickness of the sheath is reduced to 75% of that of lead. Because of this thinness, and where light metals replace copper as conductors, the actual saving in weight is 70%.

The weight of an aluminum sheath is about a quarter of that of lead of identical form. A decrease by 25% in wall thickness is possible. In armored cable 40% weight-saving may be achieved; while in unarmored cable, a saving up to 65% is possible. Aluminum also has greater tensile strength. With aluminum it is possible to produce an unsupported sheath capable of withstanding great pressure in sub-ocean laying.

It is proved that the fatigue strength of aluminum cable sheathing is four times that of lead. For cable strung overhead, its lower weight makes possible use of lighter fittings and poles, or an increase in distance between poles. With lead sheathing the lead constitutes 30 to 50% of the entire cable weight, and in special cases, 80%.

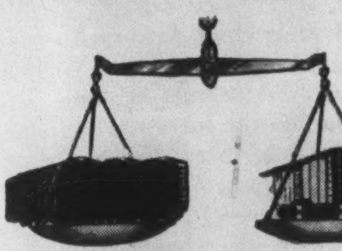
Lead, besides being low in strength, has a tendency at room temperature to recrystallization, and coarse grains can grow after installation. Of course, zinc and magnesium could be used for sheathing, but extraordinary difficulties would arise in the extrusion of the sheathing.

Thermoplastic resins and synthetic rubbers have been used as sheathings to some extent, but only where entire impermeability to moisture is not essential. The unlimited availability of aluminum offers an attractive possibility. The recrystallization temperature of aluminum is far higher than for lead. Fatigue strength is high, too.

The chief difficulty with aluminum is the work-hardening which always occurs. It will always be stiffer than lead. However, the stiffness of the sheath is only one factor

CELANESE* PLASTICS

join the model railroad brotherhood



CELANESE PLASTICS ARE LIGHTWEIGHT!

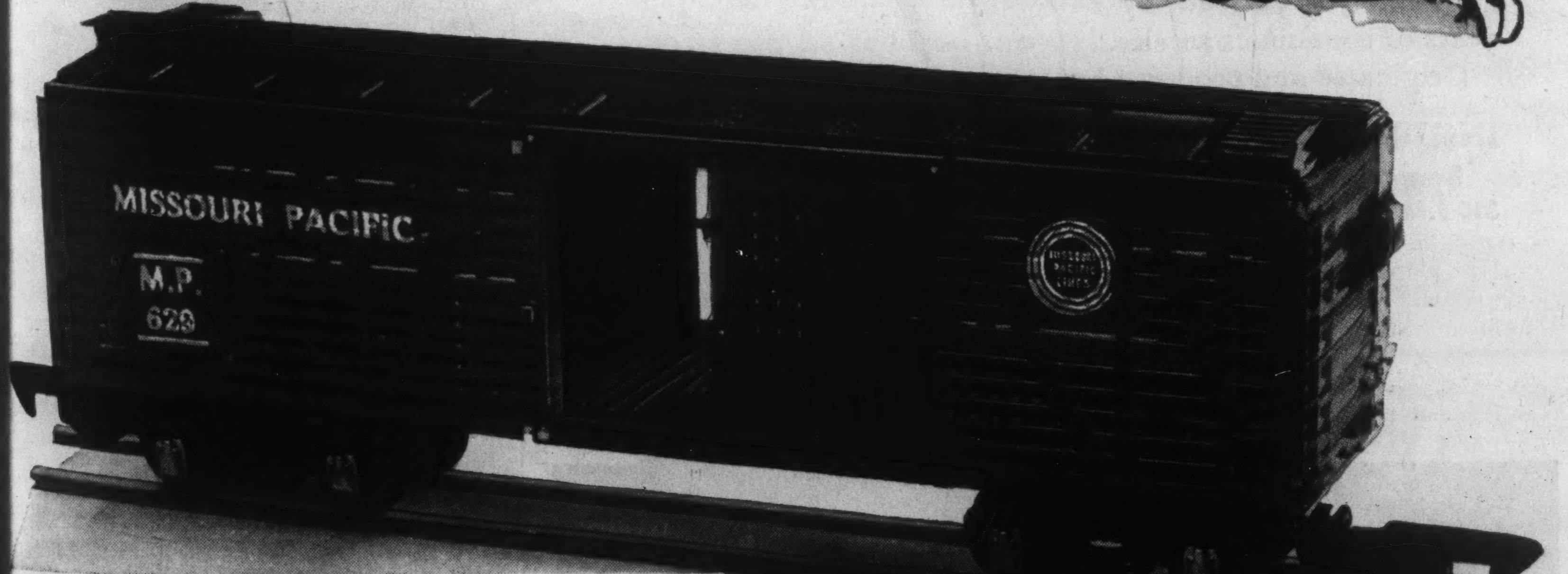
This extra-long train (22 cars) shows the increased realism plastics bring to model railroading. Celanese plastic cars are lightweight—one-third the weight of die cast metal. They make possible longer trainloads, faster pickup and higher train speeds!

CELANESE PLASTICS ARE NON-MAGNETIC!

Magnetic loading cranes work without a hitch. Cranes pick up the iron scrap but not the plastic car!

CELANESE PLASTICS ARE TOUGH!

Pile ups on the roadbed cause no damage to these cars. They are tough—can take it. Celanese plastics are color clear through—no danger of car color wearing or chipping off.



The accurate scaling and perfect details of these model cars are a tribute to good diemaking and the moldability of Celanese Plastics. Perhaps the same qualities that spell success for Celanese plastics in model railroading can be used to advantage in your products. The Celanese technical service staff is prepared to show what the high-speed moldability, clear-through color and all-around production economies of Celanese plastics can do in improving products and reducing costs. Celanese Plastics Corporation, a division of Celanese Corporation of America, 180 Madison Avenue, New York 16, N. Y.

Celanese*
PLASTICS

LUMARITH* **CELCON†** **FORTICEL*** **CELLULOID*** **VIMLITE***

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Designing new products? Modernizing your plant? Planning on new equipment? Keep an eye on the uses of IngAclad—the low-cost Stainless-Clad Steel with dozens of applications in industry today.

With its 20% cladding of solid stainless steel, IngAclad offers maximum contact-side stainless protection at minimum cost.

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in the bendability of the sheath. After many tests it is concluded that the capacity of the cable for bending is ample. The longitudinal seam produced by the method of extrusion with a divided die has qualities equal to the rest of the metal.

The stress required to fracture lead is only 30 to 40% that needed to fracture aluminum sheaths. Permanent deformation occurs at much higher pressures than for lead. Hence, aluminum can be used in thinner gages than for lead. Aluminum is usually corrosion resistant, though chlorides, alkaline hydroxides, mortar and cement are harmful.

Of course, in extrusion working, pressures of 2½ to 4 times those for lead are essential. The extrusion temperature must be raised at least 150 degrees higher than for lead. Present presses for extruding aluminum cable sheaths need further development. (*Light Metals*, Vol. 9, Sept. 1946, pp. 474-482, 483-498.)

Corrosion Resistant Metal Coatings

Condensed from "Product Engineering"

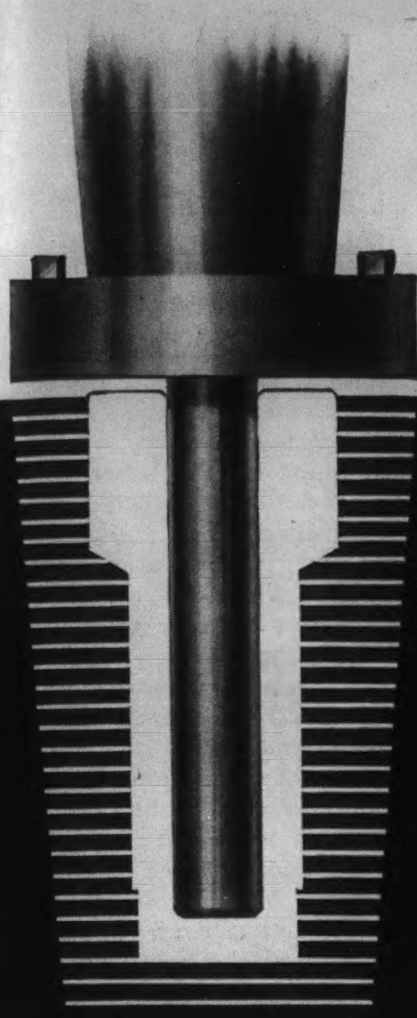
In the quest for materials, design engineers are finding an increasing variety of applications for products coated with nickel zinc and nickel tin. Both types of metal coatings, patented under the trade name of "Corronizing", offer increased corrosion resistance. The nickel-zinc Corronizing is suitable for designs where heat, water or moisture, sulfur dioxide, sulfur trioxide and other gases combine to form severe corrosive conditions; where salt spray and chemical fumes exist; and where brines and other chemical solutions are handled.

Nickel-tin Corronizing is suitable for food containers, for parts of food handling and processing equipment, and for other parts where tin plate is normally used. In addition, it is suitable where a decorative finish is desirable.

Three operations comprise the process of Corronizing. First, the base metal is electroplated with nickel. Second, zinc or tin is electroplated directly over the nickel plate. Third, the double plated part is heat-treated at a specified temperature. This heat-treating diffuses the plating materials, alloying them more or less into layers, and the composite coating offers dual protection and better corrosion resistance than nickel or zinc or tin alone.

Forming and drawing of the part can be done after Corronizing if the base metal is sufficiently ductile. Nickel-zinc Corronizing does not interfere with spot, seam and arc welding, nor with brazing and soldering operations. The nickel-tin coating can be formed, soldered and seamed like tin plate provided black oxidized stock or material of equal ductility is used as the base metal.

Cost of Corronizing can be estimated from present plating costs plus the cost of heat-treatment after plating. Cleaning solutions, concentrations of electrolytes, current density and plating procedure commonly used in electroplating are applicable for Corronizing. (L. C. Conradi. *Prod. Engineering*, Vol. 17, Sept. 1946, pp. 127-129.)



MANY PARTS CAN BE MADE FROM

BETHLEHEM *Pierced* FORGINGS

Shown above are a slush pump liner and a commutator shell, weighing, respectively, 150 and 110 pounds. They are typical of the parts that can be made by this metnod.

A lot of production men will be glad we brought this up—for here's an approach that has made substantial savings in numerous cases.

We mean the adoption of Bethlehem pierced forgings for parts that were formerly difficult and expensive to make. Here are some of the reasons why costs can be reduced through the use of these forgings:

(1) Parts formerly made with two or more pieces (plus machining, plus welding) can be made in *one* piece.

(2) The pierced forgings come to you rough-machined; annealed or heat-treated.

(3) Bethlehem's manufacturing process is economical for either small or large quantities—50 of a size and up.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

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MELTING and CASTING

Melting, alloying, refining and casting methods, furnaces and machines. Iron and steel making, nonferrous metal production, foundry practice and equipment. Die casting, permanent mold casting, precision casting, etc. Refractories, control equipment and accessories for melting furnaces.

Some Casting Troubles

Condensed from "Foundry Trade Journal"

Most of the causes of defective castings can be classified as follows: (1) Wrong alloy composition; (2) unsatisfactory melting technique; (3) incorrect pouring, gating and feeding practice; (4) poor design; and (5) bad workmanship in molds or cores.

Bronze bush casting showing inclusions of oxide and dross arising from aluminum contained as an impurity (0.25% aluminum) is cited by the author as an example of defect resulting from unsuitable composition. Factors also contributing towards the defect in this case were too low a pouring temperature and lack of deoxidation.

There is, perhaps, no metal more sensitive to melting conditions than high conductivity copper, largely because of its high solubility for gases when molten, particularly oxygen and hydrogen. Oxygen combines to form cuprous oxide, and the dissolved hydrogen is expelled as the temperature falls and the metal freezes. As the hydrogen is thrown out of solution, it reacts with the cuprous oxide to form water vapor, the so called "steam reaction." This sets up a vigorous disturbance in the metal in the mold, resulting in serious unsoundness of the casting.

To avoid this trouble, copper should be melted down under the protection of a reducing flux. Use a fast melting furnace and, during the early stages of melting, introduce about 1% of the charge weight of a suitable reducing flux. The slag cover provided by the flux should, so far as possible, be left intact as a protection to the melt until a temperature of about 2190 F (1200 C) has been reached. Generally the temperature should not exceed 2280 F (1250 C) at any time during melting. An average pouring temperature is about 2100 to 2155 F (1150 to 1180 C).

About 2 or 3 min. before pouring, some deoxidation treatment is essential. Phosphorus is not advised. Although it will deoxidize efficiently, a residue of 0.05% remaining in the melt will reduce conductivity by 30%. Other commonly used deoxidants possess a similar disadvantage, but calcium gives desired result.

During the pouring of the castings, the metal stream should be dusted with powdered charcoal to protect it from the oxygen and hydrogen in the atmosphere. Iron to the extent of 0.2% reduces the electrical conductivity of copper by 50%.

A further example of unsatisfactory melting technique is illustrated by an aluminum casting. The extensive pinhole porosity is typical of many cases in which the alloy has been raised to too high temperature and held there for too long without adequate protection from the furnace gases.

Aluminum-base alloys absorb hydrogen rapidly at temperatures above 1400 F (760 C). Melting should be conducted along the following lines: Charge the ingot and scrap together with about 0.5% by weight of a suitable flux. A suitable flux is one which will melt and form a cover on the surface of the bath and at the same time exert a cleansing action on the alloy, dissolving oxides and floating nonmetallic impurities to the surface. When the complete charge has reached a temperature of approximately 1292 F (700 C), the source of heat should be shut off, and during the ensuing temperature rise a degassing operation carried out.

Degassing is accomplished in several ways, such as passing a stream of dried nitrogen, or chlorine, through the melt and the plunging of organic compounds which evolve chlorine. For speed and convenience, organic degassers which can be plunged are hard to beat. They also have the added advantage that grain refining elements such as boron can be incorporated in their makeup.

Unsuitable molding sand, incorrect gating and feeding poor design etc. are also discussed. (J. L. Francis. *Foundry Trade J.*, Vol. 79, May 30, 1946, pp. 103-111.)

Graphitization in the Solid State and Its Industrial Application, "Malleable Iron"

Condensed from "Fonderie"

Primary graphitization at temperatures between the Acl and the eutectic is the result of the formation of graphite nuclei and their growth by a complex process consisting of dissociation of the cementite, solution of the carbon atoms in gamma iron, diffusion of the carbon atoms and their crystallization as graphite. This graphitization will continue until free cementite disappears and only graphite and austenite saturated with carbon are left.

The rate of graphitization depends upon the rates of nucleation and growth. The rate of nucleation is a function of the amount of untransformed carbon, but actually the rate of graphitization is not proportional to the number of nodules but to a fractional power (about 0.40) of this number. The rate of growth at a given temperature is determined by the rate of diffusion of the carbon atoms and by the rate of crystallization of the graphite.

For short times, diffusion is more rapid than crystallization, so the latter determines the rate of growth. For longer times, diffusion is slower and constitutes the determining factor. The rate of graphitization increases with increasing temperature more rapidly than does the rate of diffusion because the number of nuclei also increases with the graphitizing temperature.

More rapid heating increases the number of nuclei, as does quenching from above the Acl. The higher the superheating temperature of the liquid metal, the greater the number of nuclei and the faster the rate of graphitization.

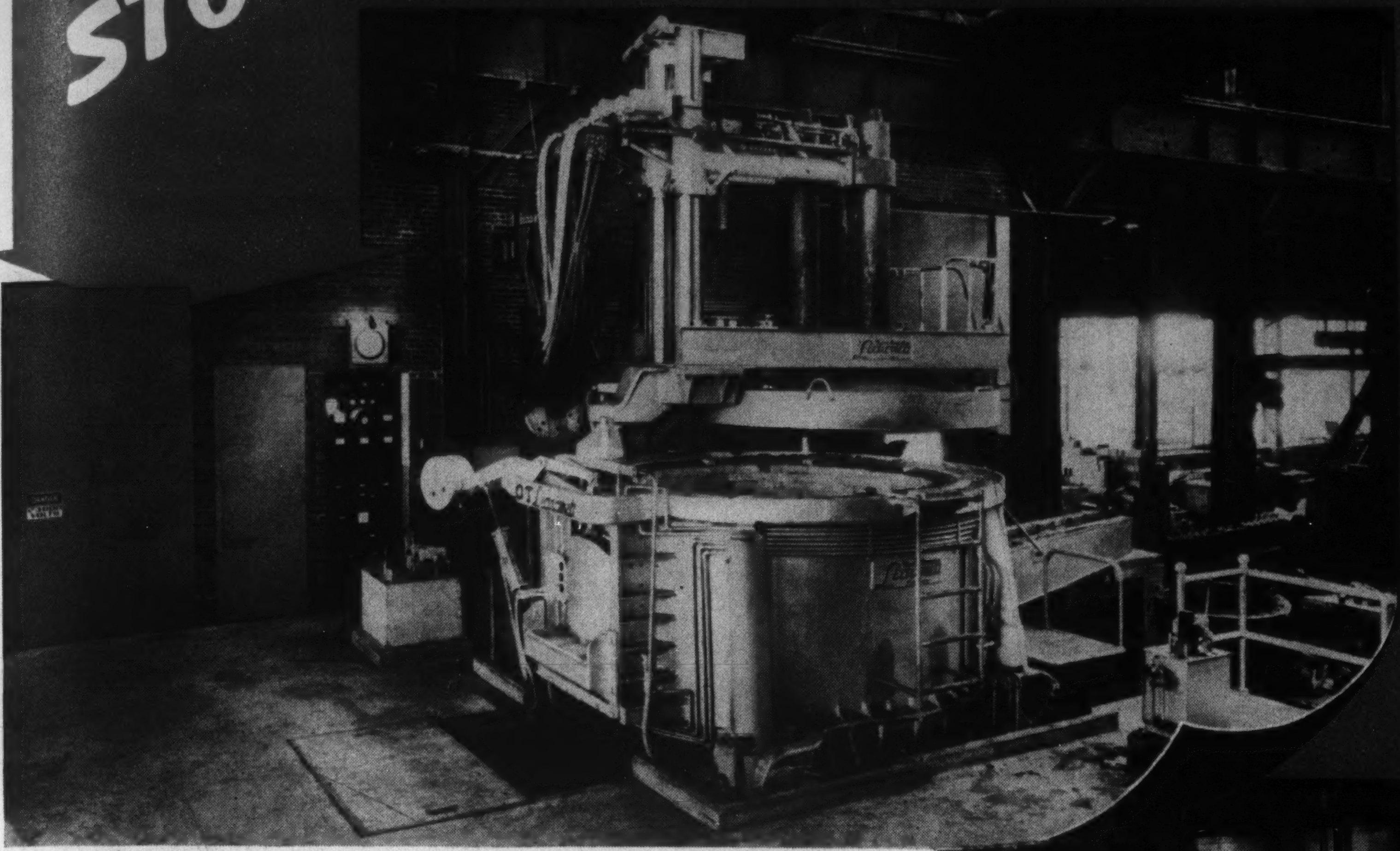
If the malleable iron is cooled slowly after primary graphitization, carbon continues to migrate to the graphite nodules in existence. If this secondary graphitization is carried to completion, American or black heart malleable consisting of graphite nodules in a ferritic matrix results.

If the malleable is cooled in air from the primary graphitization, the austenite will transform to pearlite of an eutectoid composition. With an intermediate cooling rate, the rejection of some free ferrite will occur with the formation of a bull's eye structure.

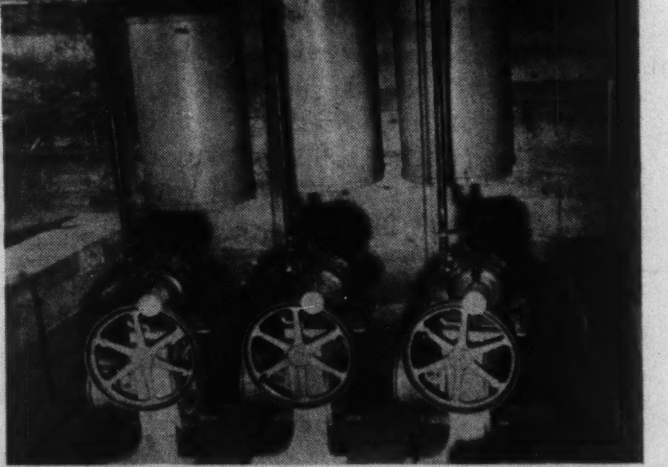
For blackheart malleable, the slow cooling may be replaced by a two step treatment: (1) primary graphitization at 1650 to 1740 F, and (2) holding between Al stable and Al metastable where the secondary graphitization is most rapid. The time required in each step depends upon composition, as indicated by the following equations: (1) time for primary graphitization at 1725 F = 5 hr x $\frac{\%C}{\%Si}$; (2) time for secondary graphitization = 12.5 hr x $\frac{\%C}{\%Si}$. A pearlitic skin due to oxidation of the silicon is not as likely to occur in the two-step treatment as when slow cooling is used.

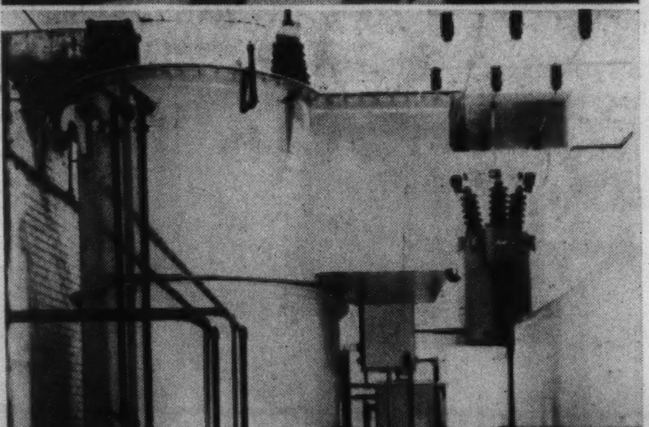
THE INSIDE STORY OF MELTING ECONOMY

MOORE RAPID *Lectromelt* FURNACES



Size "O.T." Lectromelt Furnace with roof swung aside in charging position.





The saying, "There is more than meets the eye," is especially true of a Lectromelt Furnace. The 50% of the equipment that is out of sight in the Transformer Room is also responsible for the large savings in power and electrodes and the precision quality control of a Lectromelt. The special Lectromelt transformer equipment and patented counterbalanced winch system are the major factors in the inside story of melting economy.

Lectromelt's top charge feature assures economy through faster charging and more production per man hour. Top charge furnaces are available in capacities ranging from 100 tons down to 250 pounds Write for complete information.

PITTSBURGH LECTROMELT FURNACE CORP.

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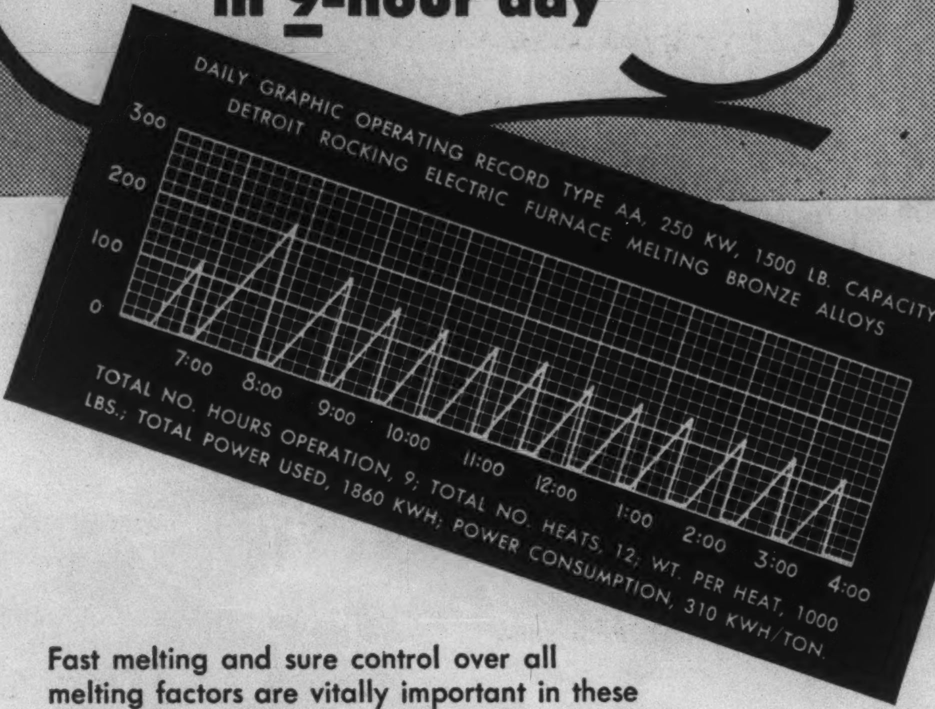
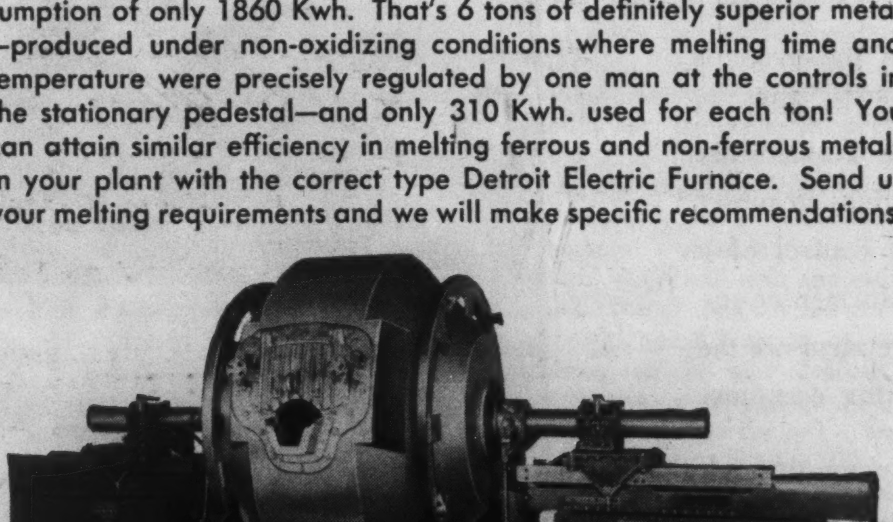
DETROIT ELECTRIC
FURNACE TYPE AA
Uses only 1860 KWH to melt
6 tons of bronze alloy
in 9-hour day



Fast melting and sure control over all melting factors are vitally important in these days of terrific demand for quality castings. Detroit Rocking Electric Furnaces insure both—plus!—ease and economy of operation that help hold down production costs. For example, consider this daily operating record of a Type AA, 250 Kw, 1500-lb. Detroit Electric Furnace. In 9 hours' operation, this furnace melted twelve 1000-lb. heats of bronze alloy at a total power consumption of only 1860 Kwh. That's 6 tons of definitely superior metal—produced under non-oxidizing conditions where melting time and temperature were precisely regulated by one man at the controls in the stationary pedestal—and only 310 Kwh. used for each ton! You can attain similar efficiency in melting ferrous and non-ferrous metals in your plant with the correct type Detroit Electric Furnace. Send us your melting requirements and we will make specific recommendations.



DETROIT ELECTRIC FURNACE DIVISION
KUHLMAN ELECTRIC COMPANY • BAY CITY, MICHIGAN

The phosphorous content should be under 0.20% to avoid the presence of the brittle steadite. Manganese indirectly favors graphitization by neutralizing the effect of the sulphur. However, amounts over 1.7 x %S + 0.20% will retard secondary graphitization. Sulphur does not affect graphitization if sufficient manganese is present; otherwise it retards graphitization. The effect of numerous other elements is mentioned briefly.

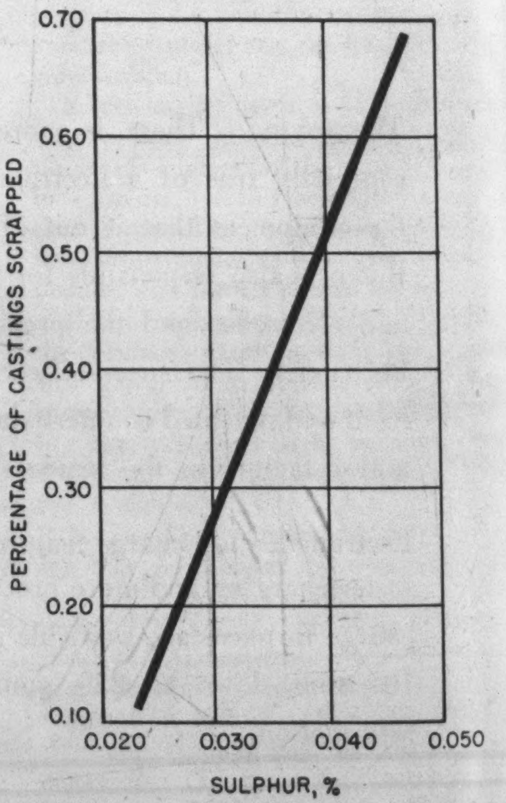
Gray iron will also graphitize if held at about the Al temperature, as the free graphite serves as nuclei. If continued long enough, this holding will result in a structure of free ferrite and graphite with no pearlite. (H. Laplanche. *Fonderie,* Apr. 1946, pp. 129-142; May 1946, pp. 169-176.)

Thin-Walled Steel Castings

Condensed from a Paper of "The Iron & Steel Institute"

Short accounts are given of the molding and founding procedures used at seven foundries in the production of thin-walled steel castings, and of the influence of the rate of pouring on the quality of the castings produced. With bomb castings less difficulty was met with when the molds were filled quickly, and also less trouble was encountered with hot steel.

There was considerable scabbing with very slow casting or with very cool steel. High rates of pouring also reduced the number of rejections due to hot tears, pulls and other defects, such as sand inclusions.



Casting temperatures above 2876 F gave better results than temperatures below, say 2822 F. With axle cases, satisfactory castings were made over a wide range of pouring speeds, but it should be noted that the casting temperatures are available for only one foundry.

DO YOU NEED A BETTER REFRACTORY?

● Corhart Electrocast Refractories are high-duty products which have proved considerably more effective than conventional refractories in certain severe services. If your processes contain spots where a better refractory is needed to provide a balanced unit and to reduce frequent repairs, Corhart Electrocast Refractories may possibly be the answer. The brief outline below gives some of the basic facts about our products. Further information will be gladly sent you on request.

Corhart Refractories Company, *Incorporated*, Sixteenth and Lee Streets, Louisville 10, Kentucky.

"Corhart" is a trade-mark, registered U. S. Patent Office.

PRODUCTS

The Corhart Refractories Company manufactures Electrocast refractory products exclusively. Corhart Electrocast Refractories are made by melting selected and controlled refractory batches in electric furnaces and casting the molten material into molds of any desired reasonable shape and size. After careful annealing, the castings are ready for shipment and use.

Three Electrocast refractory compositions are commercially available:

CORHART STANDARD ELECTROCAST — a high-duty corundum-mullite refractory, with density of approximately 183 lbs. per cu. ft.

CORHART ZED ELECTROCAST—a high-duty zirconia-bearing aluminous refractory, with density of approximately 205 lbs. per cu. ft.

CORHART ZAC ELECTROCAST—a high-duty zirconia-bearing refractory, with density of approximately 220 lbs. per cu. ft.

Other Corhart products are:

CORHART STANDARD MORTAR—a high-temperature, high-quality, hot-setting cement for laying up Electrocast, or any aluminous refractory.

CORHART ACID-PROOF MORTARS — rapid cold-setting, vitrifiable mortars of minimum porosities.

CORHART ELECTROPLAST—a high-temperature, hot-setting plastic refractory, designed for ramming and made from crushed Standard Electrocast.

CORHART ELECTROCAST GRAINS—Standard Electrocast crushed to desired screen size for use in many commercial applications.

PROPERTIES

Due to the unique method of manufacture, the Electrocast refractory line possesses a combination of characteristics found in no other type of refractory. Data on properties will be sent on request.

POROSITY: Apparent porosity of Corhart Electrocast refractories is practically nil—therefore virtually no absorption.

HARDNESS: 8-9 on Mineralogist's scale.

THERMAL EXPANSION: Less than that of conventional fire clay bodies.

THERMAL CONDUCTIVITY: Approximately one and one-half times that of conventional fire clay bodies.

REFRACTORINESS: Many industrial furnaces continuously operated up to approximately 3000° F. are built of Corhart Electrocast.

CORROSION: Because of exceedingly low porosity and inherent chemical compositions, Corhart Electrocast refractories are resistant to corrosive action of slag, ashes, glasses, and most non-ferrous metals as well as to disintegrating effects of molten electrolyte salt mixtures.

APPLICATIONS

Most heat and metallurgical processes present spots where better refractory materials are needed, in order to provide a balanced unit and reduce the expense of repeated repairs. It is for such places of severe service that we invite inquiries regarding Corhart Products as the fortifying agents to provide the balance desired. A partial list of applications in which Corhart Electrocast products have proved economical follows:

GLASS TANKS—entire installation of sidewalls and bottoms, breastwalls, ports, tuckstones, throats, forehearths, bushings, bowls, recuperators, etc., for lime, lead, opal and borosilicate glasses.

ELECTROLYTIC CELLS—for production of magnesium and other light metals.

SODIUM SILICATE FURNACES — sidewalls, bottoms, and breastwalls.

PIGMENT FRIT FURNACES—complete tank furnaces for melting metallic oxides and salts for pigment manufacture.

ALKALI AND BORAX MELTING FURNACES—fast-eroding portions.

BOILERS—clinker line.

RECUPERATORS—tile, headers, separators, etc.

ENAMEL FRIT FURNACES—flux walls and bottoms.

BRASS FURNACES—metal contact linings.

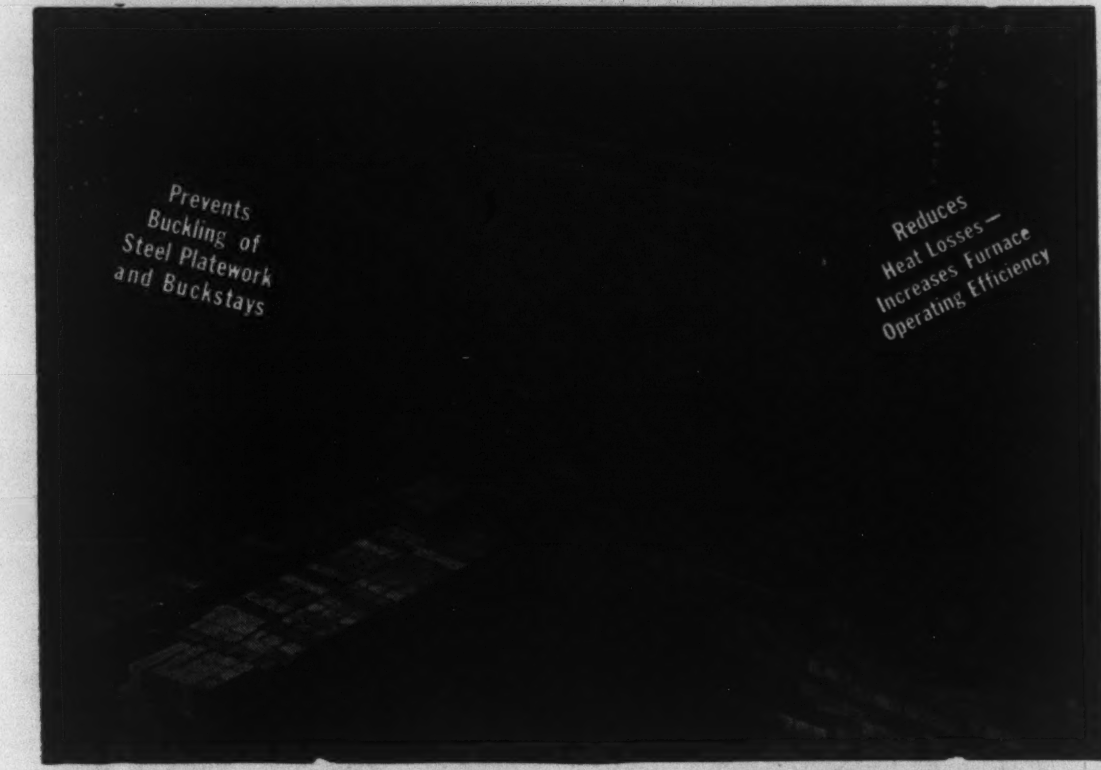
ELECTRIC FURNACES—linings for rocking type and rammed linings of Electroplast for this and other types.

NON-FERROUS SMELTERS—complete hearths, sidewalls, and tapping hole portions.

QUALITY ECONOMY ENDURANCE

CORHART ELECTROCAST REFRACTORIES

This
LIGHTWEIGHT INSULATING BRICK
does "Double Duty"
in Furnace Walls


Prevents Buckling of Steel Platework and Buckstays
Reduces Heat Losses— Increases Furnace Operating Efficiency

CONVENIENT 13½ x 9" SIZE—EASY TO HANDLE
REDUCES WALL JOINTS 65%

Other forms of THERM-O-FLAKE INSULATION

Coating — Seals and Insulates all types of furnace walls. Highly plastic, works and spreads easily.

Blocks — Highly efficient insulation where larger size units may be required.

Concrete — Monolithic castable insulation with high insulating value.

Granules — Loose-fill, efficient insulation, weighs only 6 pounds per cubic foot.

Protects furnace steelwork and plating from excessive heat with a strong resilient cushion which absorbs expansion stresses.

KEEPS HEAT INSIDE FURNACE WALLS

Excellent insulation,— a 4½ inch thickness being equivalent in heat flow resistance to more than 29 inches of fire brick.

Find out how quickly THERM-O-FLAKE Brick will pay back their cost in reduced furnace heat losses. For specific data, indicate type of furnace and approx. operating temperatures in writing to:

Illinois Clay Products Company
JOLIET, ILLINOIS
Therm-O-flake BRICK
FOR HOT FACE TEMPERATURES UP TO 2000° F.

Since the foregoing particulars were submitted, further work has been done by one of the reporting Members, and it has been found that with a pouring speed of under 35 sec. the rejections due to the formation of hot tears and pulls are reduced to approximately 2%, and the rejections due to other causes, such as sand inclusions, are also considerably decreased.

One of the reporting Members found that the extent of hot tears in these thin-walled castings increased as the sulphur content of the steel increased. Tests covering 2307 castings (286 heats) are shown in Fig. 1.

Another factor affecting hot tears, or cracks, in castings of this type is the strength of the core. One core, which gave good results, consisted of wood wool wound on a steel core, which was then wire bound, covered with the sand mix, dried, then painted while still hot, with silica paint.

Tabulated operating conditions of the two Members reporting on the casting of steel axle cases indicate that they have, in general, used ladle temperatures of the order of 2850 F and pouring speeds of the order of 20 sec. for castings of approximately 200 lb. (Foundry Practice Sub-Committee, *Iron & Steel Inst.*, Preprint No. 19, Apr. 1946, 16 pp.)

Second Report on the Basic Cupola

Condensed from "Foundry Trade Journal"

The experiments described in this report confirm that some dephosphorization can be obtained during melting in a basic-lined cupola. The abnormally high pick-up of carbon reported by Heiken (*Die Giesserei*, Nos. 43 and 44, Oct. 28, 1934, as abstracted in *Foundry Trade J.*, Vol. 72, Mar. 2, 1944) is also confirmed, and it was found that appreciable desulphurization can be obtained simultaneously with dephosphorization.

With high-steel charges of the type used in the cupola-converter process there is no difficulty in producing conditions under which phosphorous may be removed, but with this type of charge there is a serious danger that such conditions will result in the production of metal unsuitable for further processing.

It was found that the stabilized dolomite material is satisfactory as a lining for a cupola and the stabilized dolomite cement is a satisfactory patching. The lining material, and more especially the patching, were more expensive than the conventional acid materials.

A total of 663 tons of metal was melted with an average consumption of refractories of 69 lb. per ton of metal melted, which includes an estimate of the patching required to repair the lining after the final melt. The lining failed through flaking of the monolith, which first appeared after the first melt and grew progressively worse. It is pointed out, however, that the efforts made to produce oxidizing conditions in the cupola during the experiments may have increased the rate of lining attack. (*Foundry Trade J.*, Vol. 79, July 4, 1946, pp. 239-243.)

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Foundrymen who have used Michigan Smelting Brass and Bronze ingot will tell you they like to work with it. M.S.R. protects them from the basic casting defects that arise when scrap mixes or inferior grade metals are used. Michigan Smelting ingot is made to your exact specifications—will enable you to produce a quality product.

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NON-FERROUS SCRAP METAL REFINERS FOR OVER 50 YEARS

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General Offices—Lafayette Building

FABRICATION and TREATMENT

Machining, forging, forming, heat treating and heating, welding and joining, cleaning and finishing of solid materials. Methods, equipment, auxiliaries and control instruments for processing metals and nonmetals and for product fabrication.

Wet Belt Machining

Condensed from "Modern Machine Shop"

Wet belt machining has increased production and lowered manufacturing costs in many cases by avoidance of expensive jigs and fixture making; reduction in loading, machining, and unloading time; faster cutting; fast free-hand surfacing without costly holding devices; application to a wide range of operations; and adaptability to all kinds of metallic and nonmetallic materials and shapes.

It is a method of grinding, surfacing, and stock removal by the cutting action of an abrasive belt, traveling at 2500 to 4500 surface ft. per min. The belt passes over top and bottom pullies, gliding midway down, over a hardened steel platen and past a work table.

A coolant is applied by means of a spray nozzle located directly above the work at the point on the belt where work contact is effected. A ratio of 40 parts water to one part soluble oil is recommended. Another spray nozzle is buried inside the machine below the work table and constantly flushes the belt during the cutting operation.

The backbone of the process is the platen. It is usually a hardened steel plate, perfectly flat, and is mounted on a backing plate, which, in turn, is mounted on the frame of the machine. It can be adjusted by means of set-screws for squaring the platen with the work table.

A hardened steel platen is advantageous for holding very close tolerances or when establishing flat surfaces. A resilient platen is used when perfect flatness is not specified, convex- or concave-shaped surfaces are to be ground, or a high polish is desired. The belt follows the contours of the platen and lies snugly against it. The ends of the platens are slightly chamfered to facilitate movement of the belt.

Removal of too large a quantity of stock is uneconomical. On nonferrous metals, removal of ⅛ or 1/32 in. is common. On ferrous metals, this varies considerably because of the area of the piece involved. In most applications, 5 to 30 sec. are required to remove the desired amount of stock. Tolerances obtained are 0.002 to 0.0005 in.

Belts are impervious to water and soluble oil and are of cloth backing, with the abrasive plastic bonded to the belt. Abrasives are aluminum oxide and silicon carbide. The belt is coated electrostatically.

For efficient platen grinding and surfacing, there are required sufficient work pressure to obtain maximum cutting efficiency, and a mechanical aid to control the amount of stock in-feed to obtain close accuracy. An automatic feed table has been developed for these purposes. It is equipped with an hydraulic control for controlling the rate of feed. A micrometer stop fixes the point at which the hydraulic control should cease operating when the belt has removed the desired amount of stock. (William T. Schleicher. *Mod. Mach. Shop*, Vol. 19, Aug. 1946, pp. 124-132, 134, 136.)

Gaseous Malleablizing

Condensed from "Foundry Trade Journal"

Admission of steam into the furnace atmosphere during the annealing of iron castings results in the production of a gaseous mixture which consists mainly of carbon monoxide, carbon dioxide, hydrogen and water vapor, and which is nitrogen free. The mixture may contain up to 40% decarburants without oxidation of the iron occurring. Atmospheres produced by combustion of fuel gas or hydrocarbon usually contain up to 10%. These figures give some comparison of the relative decarburizing power of the two types of atmosphere.

The charge used for testing was contained in three nickel chromium baskets with grid bases, each basket having a capacity of 1⅓ cu. ft. of ⅛-in. thick conduit fittings. Atmosphere circulation was effected by a fan situated beneath the baskets, and steam admissions were made through a pipe at the top of the furnace chamber. During the heating up period, frequent analyses of the furnace atmosphere were made.

In the early stages, oxidation of the iron took place and the oxide thus formed was later reduced by the carbon diffusing to the surface of the charge as it came up to heat. The rate of steam addition necessary to maintain the correct atmosphere rose to a peak value and then fell away fairly rapidly for all the samples tested. The time at which the addition of steam was discontinued and the furnace switched off was determined from experience gained in previous anneals.

All charges were allowed to cool in the furnace. For a fixed weight of charge and heating cycle, there is an optimum rate of steam addition. Photomicrographs are shown illustrating the pearlitic microstructure resulting from a satisfactory treatment. Hundreds of castings from many sampling points were tested and no failure under bend occurred.

From the results obtained it was noted that it is desirable to segregate castings into charges lying within a certain range of thickness; an increase in the unit weight of the charge treated will result in a slower heating-up time and thus, in a flatter peak in the decarburant addition curve. The rate of decarburant addition required is a measure of the progress of the anneal. The circulating fan used in the annealing chamber must give a rapid flow of gas to insure uniform temperature and decarburization. (D. M. Dovey. *Foundry Trade J.*, Vol. 79, Aug. 1, 1946, pp. 347-351.)

Cemented Carbides For Forming

Condensed from "Machinery"

Carbide dies for the drawing of round wire are now generally considered standard equipment throughout the wire industry. The smallest steel wire being drawn through carbide dies at present is believed to be 0.005 in. in dia. Copper and bronze wire down to 0.062 in. dia. is being drawn in such dies, and tungsten wire as fine as 0.006 in. is regularly produced with carbide dies.

Production records show that carbide dies outlast the formerly used conventiona steel dies at least 20 to 1 for ordinary wir drawing. They also insure greater uniformity of product and a better finish.

Carbon steel, stainless steel, and nonferrous metals are being deep-drawn i carbide dies that frequently have a life o from twenty to one hundred times that o comparable steel dies. The carbide di

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. . . . you can drill, bore, ream and tap

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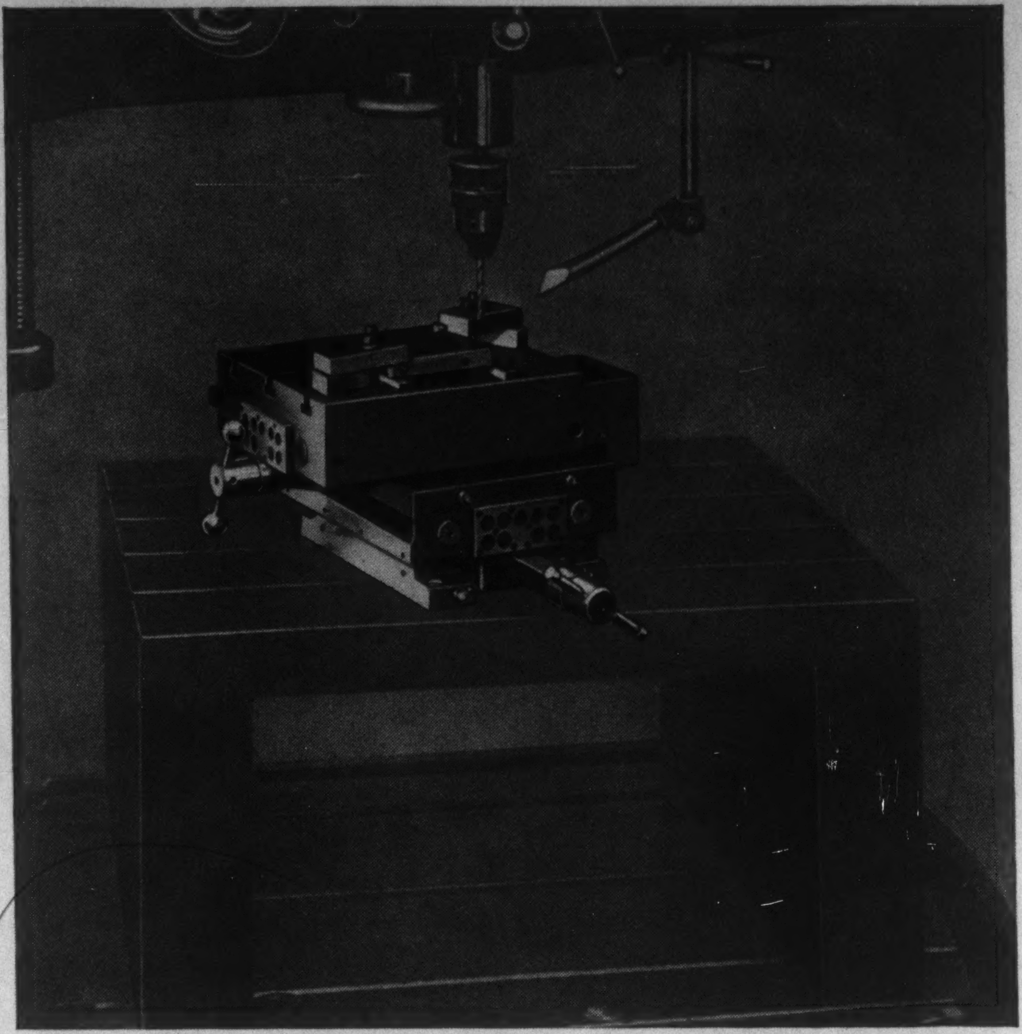
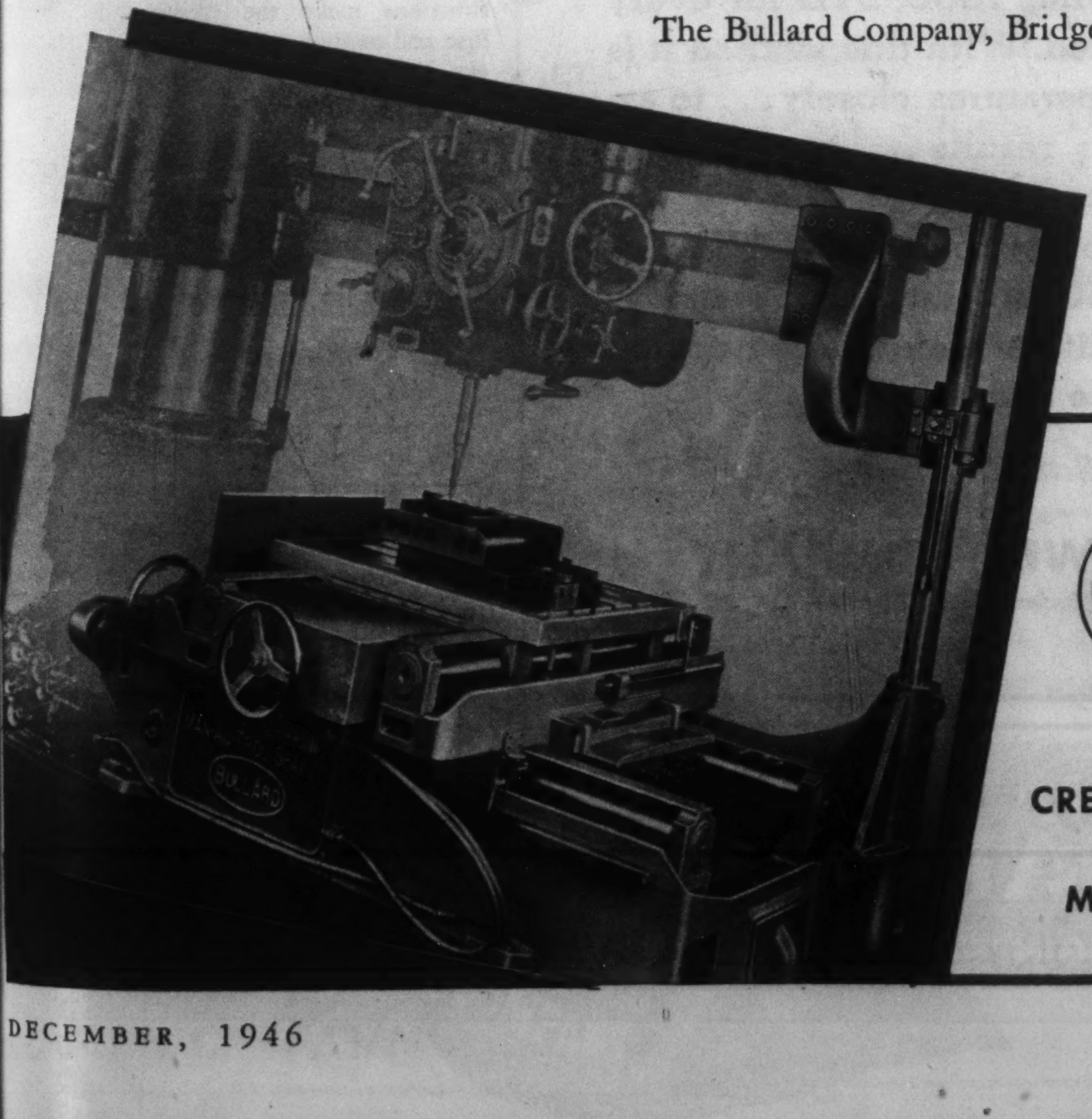


The new 4″x 4″ Bullard MAN-AU-TROL Spacer for speedily and accurately locating holes within a 4″x 4″ area . . . for use on smaller sensitive drills but usable on larger drills as shown. Its hydraulic unit will operate four 4″x 4″ Spacers if you so desire.

. . . as well as LARGE WORK

The new 30″x 20″ Bullard MAN-AU-TROL Spacer for accurately repeating a pattern of holes within a 30″x 20″ area . . . for use on radial drills.

BOTH the 4″x 4″ and 30″x 20″ Bullard MAN-AU-TROL Spacers give you such benefits as: elimination of expensive jigs . . . no production tie-ups for making jigs . . . straight holes 90° to the work . . . prevention of strain on drill spindle and reduction of drill wear because of perfect tool centering . . . less operator fatigue. Write for MAN-AU-TROL Spacer Bulletin. The Bullard Company, Bridgeport 2, Connecticut.



Typical Installation of 30″x 20″ MAN-AU-TROL Spacer.

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CREATES ***NEW METHODS***
TO MAKE
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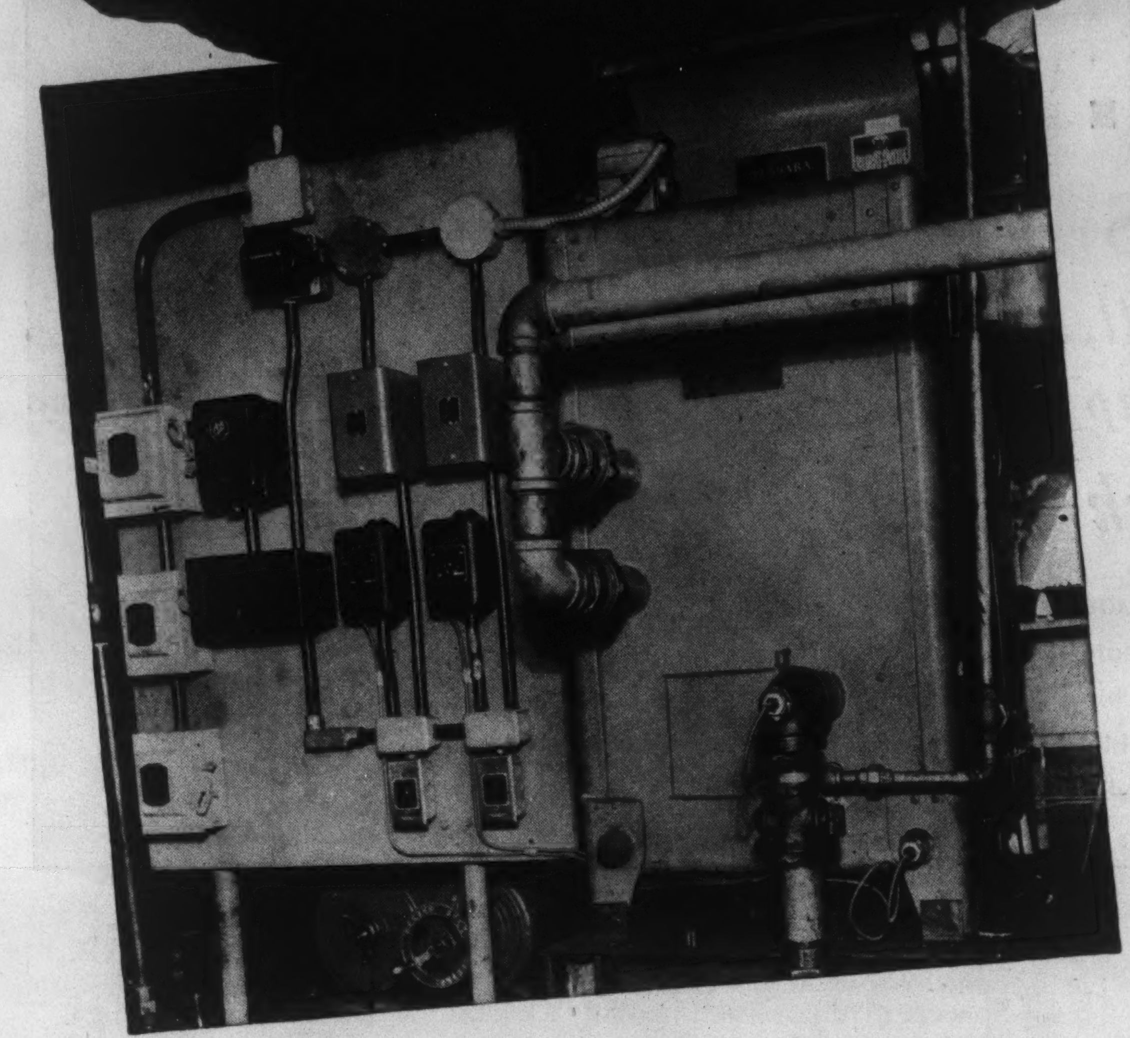
LET *Air* DO THE WORK OF COOLING



• **The NIAGARA AERO HEAT EXCHANGER makes the atmospheric air take up the heat you want to remove from power equipment or industrial process. It is done by the evaporation of a small amount of water, removing 1000 BTU for every pound of water evaporated. With this method it is also easy to control temperatures closely . . . to assure accuracy in process results . . . speeding up production at lower cost.**

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used at present have inside diameters up to 13½ in.; sheet steel up to 3/32 in. thick is being regularly drawn. It is said that the use of carbide dies on a large scale has reduced scrap by 50% in this plant. It has also increased the number of pieces passing inspection by 30%, and it has materially improved the product by eliminating surface defects in the finished drawn parts. Conventional steel dies needed repolishing after an average of 2500 draws. Carbide dies do not require such attention until after performing about 10,000 comparable operations.

In the manufacture of stator laminations for electric motors, carbide punches and dies are advantageously employed. Regular steel dies and punches produced 46,000 punchings before resharpening. Carboloy punches and dies have produced as many as 2,304,000 pieces between sharpenings.

Cold-forging with carbide dies has promising possibilities, judging from the results obtained in the cold-nosing of 75-, 90- and 105-millimeter shells during the war. The application of carbide dies reduced the die cost by 80%. It also reduced maintenance costs and decreased the "down" time of the presses, since the carbide dies outlasted similar steel dies forty times.

Cemented-carbide sleeve bearings and ball bearings have also been tried out on an experimental basis. Carbide balls are now being used to support the heavy moving tables on such machines as large planers and grinders. In all cases so far reported carbide balls have stood up far longer than the hardest steel balls.

In the telegraph communications field, electrical contacts made of Carboloy are reported to be giving materially better service in modern high-speed telegraph transmission than the formerly used metals, such as silver, platinum, and a hard alloy of platinum and iridium. The high speeds at which modern telegraphic apparatus functions make the conventional metals fuse and oxidize. (K. R. Beardslee. *Machinery,* Vol. 52, Aug. 1946, pp. 150-156.)

Phosphate Processes for Metals

Condensed from "Sheet Metal Industries"

Phosphating is a chemical process in which iron, steel, zinc or cadmium surfaces are treated with an aqueous solution which consists essentially of either zinc, manganese or iron phosphates (or mixtures of these), together with a small quantity of free phosphoric acid. As a result of the ensuing chemical reaction, the metal is converted into a layer of insoluble crystalline phosphates, integral with the base metal, which forms an excellent base for subsequent painting, enamelling or lacquering, etc., or for staining and oiling.

Owing to their crystalline and porous nature, the phosphate coatings have no highly corrosion-resistant properties unless they are used in combination with a film of paint, lacquer or other organic finish. At the present time, the coatings produced

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You'll like the way
Hagan designs and builds
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Cut Powder Metal Blending Costs
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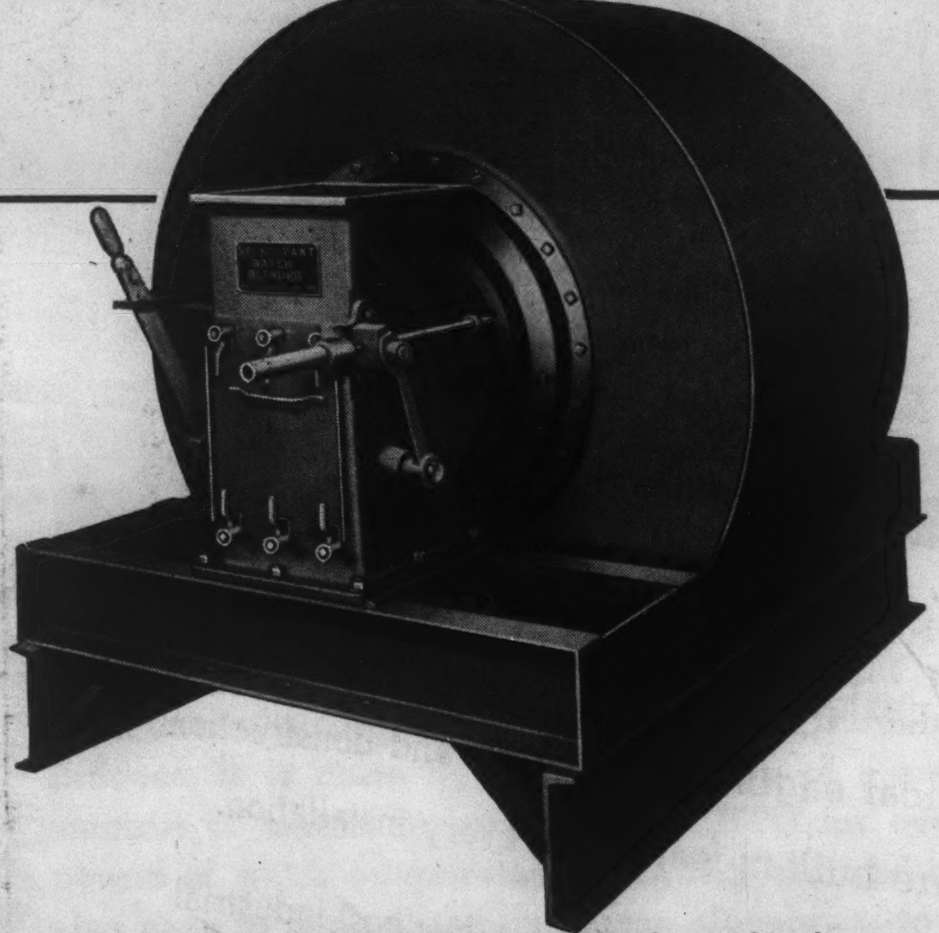

Sturtevant Blenders will speed up your powdered metal blending providing perfect homogenous blends regardless of the varying densities, weights or finenesses of the powders.

The 4-way mixing action assures perfect batches with no substances floating to remain unmixed. As materials are received they are picked up by revolving buckets and cascaded from the top of the machine. At the same time the drum revolves forcing the powders from both ends toward the center of the drum . . . while the swinging chute, which is in blending position produces a fourth lateral mixing action.

Heavy rugged construction assures long life. Open-door accessibility permits quick, easy cleaning. Available in sizes from 1000 to 7500 pounds. Write for information.

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Designers and Manufacturers of
CRUSHERS • GRINDERS • SEPARATORS • CONVEYORS
MECHANICAL DENS and EXCAVATORS • ELEVATORS • MIXERS

can be broadly classified according to the time required for their formation. The coatings produced in 30 to 60 min. by the long treatment time processes are largely used for processing small articles where the requisite degree of corrosion protection is afforded by an oil or stain finish. The accelerated processes, requiring from 7 sec. up to 10 min. are used almost exclusively as a base for painting, enamelling or lacquering.

The crystal size and adhesion to the base metal of a phosphate coating affects its protective value. Both these factors are influenced by the method and efficiency of the cleaning operation, and thus, the importance of pre-cleaning can not be overemphasized.

Water rinsing after phosphating produces clean work by removing loose matter and by washing out traces of processing solution which would otherwise be dried on to the surface. After water rinsing but before drying and painting, it is best practice to give the phosphate coating a further warm dilute chromic acid or dichromate rinse.

In addition to the application of phosphate treatments for ferrous alloys, they are now being employed in the nonferrous field, especially for the treatment of zinc. It is common knowledge that adhesion of paint to zinc is poor, but remarkable increase in the life of paint on phosphated zinc has been demonstrated. Phosphate coatings are also used as an aid to lubrication, through the formation of an oil retentive parting layer, which prevents metal to metal contact, and thus reduces "scuffing". (H. A. Holden. *Sheet Metal Inds.*, Vol. 23, Aug. 1946, pp. 1539-1546.)

Predetermination of Pulling Force in Drawing Steel

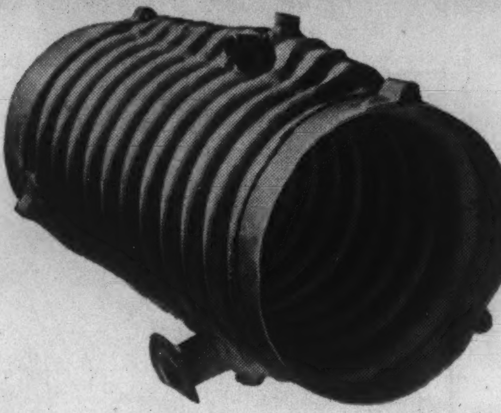
Condensed from "Mitteilungen aus dem Kaiser-Wilhelm-Institut für Eisenforschung zu Düsseldorf"

A series of tests was made with carbon, chromium, 18:8 and chromium-vanadium steels in order to find a simple method to predetermine the pulling force; the drawing die had an opening of 17 mm. and an entry angle of 20 deg. The very elaborate tests (described in full) permitted the establishment of the required pulling force equation.

A four-part nomogram was developed from which the pulling force can be taken for steels with hardness from 100 to 500 Brinell, for a reduction up to 30% and pulling forces up to 200 tons.

The values from the nomogram can also be used for other angles of the drawing die than 20 deg. if the effect of the angle on the pulling force is known. In this manner it is possible to find the most economical utilization of existing and the actual requirements for new plants without overmotoring the machines. (W. Lueg & A. Pomp. *Mitt. Kaiser-Wilhelm Inst. Eisenforsch. Düsseldorf*, Vol. 27, No. 4, 1944, pp. 43-52.)

2 SERVICE STORIES
to help you choose a durable metal for HEAT TRANSFER equipment



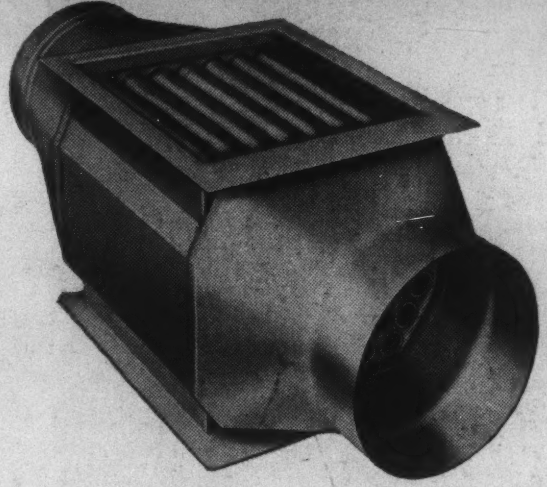
This **flash-type boiler** (located in the engine exhaust stack of airliners) provides a uniform cabin temperature of 70° F.

Heated by the exhaust, the sealed-in water supply is converted into steam for cabin heaters. After giving up its heat, the steam is condensed and returned to the boiler.

These boilers, made entirely of one metal, must stand stack temperatures in excess of 1500° F. In addition, they must endure the sudden shock of the 200° F. return water. And, they must remain free from scale and corrosion for top efficiency.

Inconel (an 80 Nickel-14 Chromium alloy) has long been specified for this tough job. The reason is readily apparent. Just look at the boiler shown. After 1100 hours' service, it is still in almost perfect condition.

You need more than good conductivity —you need a metal whose surface will remain free of corrosion and scale



Here's a **heat exchanger** used on Lockheed planes. Taking heat from the engine exhaust gases, it supplies large volumes of hot air to de-ice wings.

The entire unit is made of *one* metal.

That metal must—

... withstand the searing heat of exhaust gases without suffering serious oxidation

... stand up under the corrosive attack of high-octane exhaust

... permit a strong, yet lightweight, unit that can withstand the vibration stresses

... endure the thermal shock of sub-zero intake air and the hot blast of exhaust gases

... undergo all the fabricating operations that must be employed to shape the parts and assemble them into a complete unit.

The one metal offering all these properties is *Inconel*—an INCO Nickel Alloy.

Before Inconel was tried, previous designs failed in less than 100 hours. With Inconel, Lockheed now gets the desired performance and life.

If you have a heat transfer problem that thermally durable Inconel might solve, send for: "HEAT TRANSFER THROUGH METALLIC WALLS."

Or, if you have any application where you want long life at high temperatures, investigate Inconel. INCO Technical Service is always ready to help you work out individual designs.

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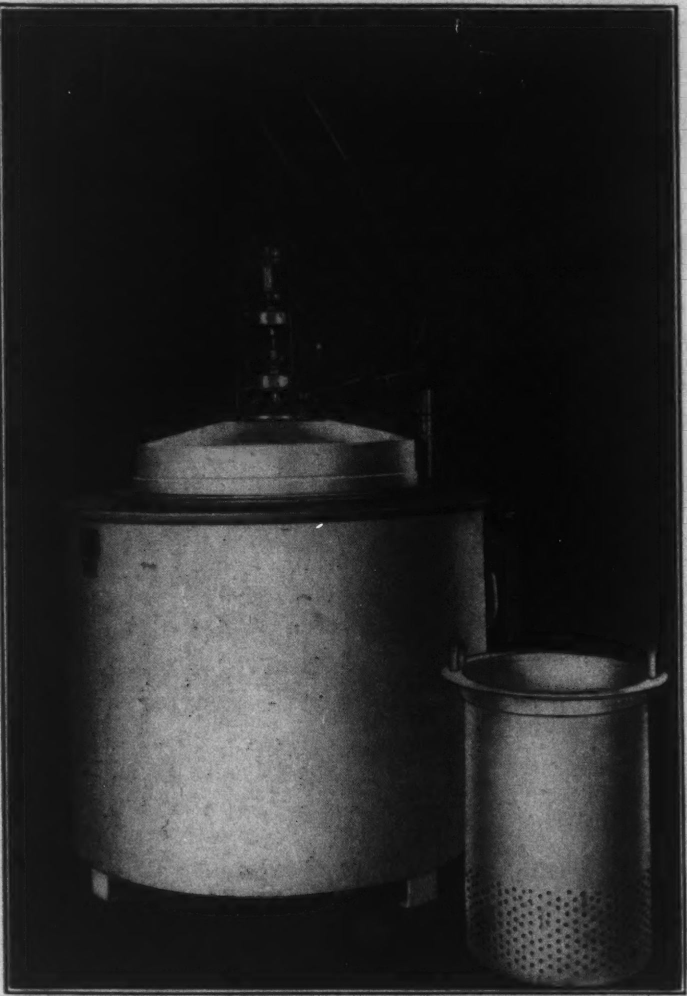

Model NA1620 Furnace With Container

The "AMERICAN" Method for Tempering enables men to bring big loads, regardless of density, quickly and smoothly to soak, resulting in rejections being held to a minimum or eliminated. This furnace is so compactly built that it requires little floor space. Work is usually brought to the furnace quickly by overhead conveyor permitting most efficient use of floor space.

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Industrial Furnaces For All Purposes

Freeze Fitting

Condensed from "Steel"

Mechanical refrigeration equipment has been installed in the assembly line at a Detroit automobile manufacturing plant to chill shrink steel valve inserts for fitting into cylinder blocks. Inserts chilled at minus 120 F shrink 0.002-in. and are automatically ejected from the freezing unit. In room temperatures, the inserts expand to normal size and become a permanent part of the block.

In the cold treatment of metals, subzero temperatures are applied to assure hardness and uniformity. In both ferrous and nonferrous metals, a time cycle alternately subjecting parts to heat and cold is required to stabilize the metal completely.

Although from 2 to 5 cycles are recommended, the exact number depends upon the degree of stability required. The final cycle is best followed by a draw at temperatures of from 200 to 300 F.

Production was increased and costs reduced through the cold shrink fit assembly of airplane landing struts and of a bushing in the piston of a diesel engine. A bevel gear assembly into a spline shaft permitted fitting of the gear with a hand-operated arbor press.

During the war, cold treating of close fitting parts of aircraft permitted free working of the parts at high altitudes. (*Steel*, Vol. 119, Aug. 12, 1946, p. 96.)

Surface Finishing Light Alloys

Condensed from "Light Metals"

The potentialities of light alloys in the industrial and domestic fields are immense; and much that has been learned during the war regarding their uses is now being applied. The two methods which are available for their protection, namely, the chemical treatment and the application of organic protectives, will be discussed with the emphasis on the latter. Chemical treatments will be touched only in so far as they serve as surface preparation for organic coatings.

The main problems associated with the surface coating of metals are the difficulty of satisfactory adhesion, the need for flexibility of film, and the need for a film having a coefficient of expansion comparable to that of the metal on which it is to be spread. Adhesion problems may be answered by surface roughening or by paint formulation in accordance with the adhesive powers of the resins used.

Priming coats are normally developed purely for adhesive purposes and have a higher content of inorganic material than finishing coats. Research has shown that certain metallic chromates and silicates are the best as pigments for light alloy primers. Thorough cleaning is, of course, a necessary prerequisite.

The choice of the finishing material will depend on the conditions to which the part will be subjected; and the choice of the finishing method will depend on the size of the article and the degree of hardness which is required. Generally speaking,

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Any woman's heart will yearn for one of the new, beautifully styled and enamelled "Universal" electric ranges made by Landers, Frary & Clark. Beneath the smooth, rich, glowing surface of that enamel is iron and steel which had to be clean as a whistle before coating and firing.

MANY REJECTS VS. "PERFECTION"

Under old methods of cleaning and pickling much of the work was rejected. Under a new method, developed with the help of a Pennsalt representative and Pennsalt products, the work was judged "perfect."

NO TANKS OR SOAKING . . . ALL SPRAY

In an enclosed unit, parts now move on an overhead conveyor; are never dipped. All cleaning, pickling and rinsing is done by sprays. Fumes are eliminated by a water wash. Pennsalt cleaners are used exclusively.

WHAT IS YOUR METAL CLEANING PROBLEM?

Pennsalt men have helped many manufacturers to turn out *better work—faster—at lower cost*—they may be able to help you. Write or wire to our Philadelphia headquarters and add our experience to your own.

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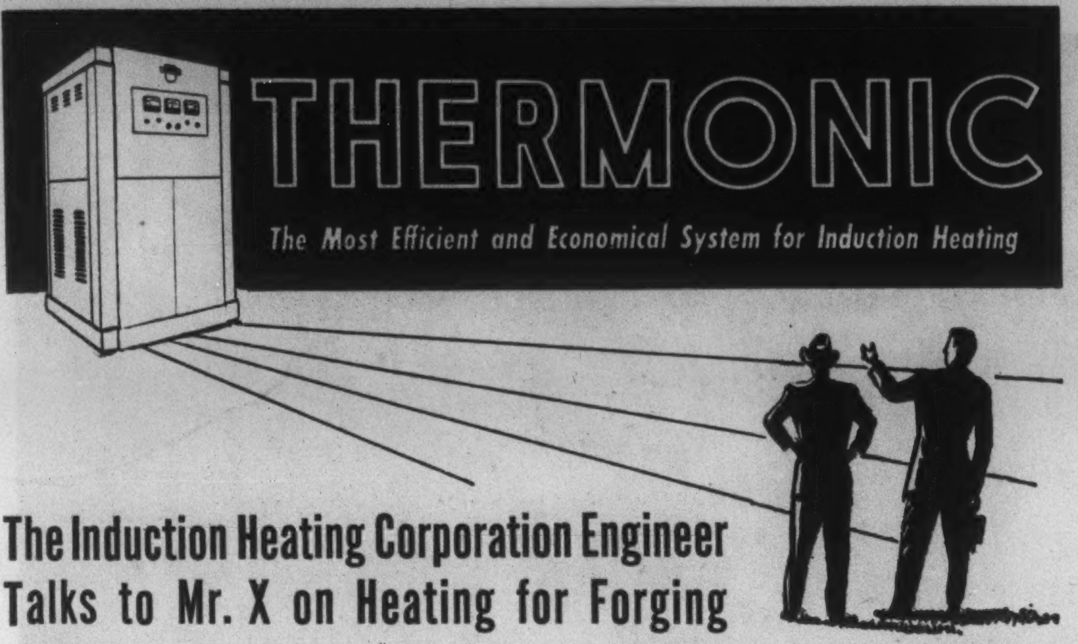

THERMONIC
The Most Efficient and Economical System for Induction Heating

The Induction Heating Corporation Engineer Talks to Mr. X on Heating for Forging

MR. X: I gather, from what you've told me about induction brazing, that heat penetrates through the entire joint area. I thought induction heating was suitable for surface heating only.

ENGINEER: I'm afraid I've given you the wrong impression. While it's true that electrical energy is converted to heat energy at the outermost surface of the metal being heated inductively, this heat tends to be conducted into the inner layers, resulting in a definite temperature gradient across the material. The steepness of this gradient depends on the conductivity of the metal and the relative rates of energy input to the heat-generating layer. In the case of surface hardening, the input rate is maintained as high as possible in order to confine heat to the outer surface and remove it by quenching before it can be conducted to the interior. For forging work, however, where deep heating is required, the input rate per unit of surface area is lowered so that the temperature gradient from outside to inside is flat or negligible.

MR. X: Just how does your THER-MONIC Induction Heating equipment fit into the forging shop?

ENGINEER: Induction heating equipment is installed on the production line next to the forging machines. Parts are rapidly brought up to forging temperature and are fed in a continuous, steady flow to the forging machines. One of the main advantages of using induction heating for forging is its short heating cycle, compared to furnace methods, and the resultant minimum of scale.

MR. X: How can induction heating minimize scale?

ENGINEER: Because induction heating equipment heats parts with great rapidity, they are at the high temperature where scale takes place for a relatively short time, compared to overall heating methods. Thus, very little or practically no scale formation results. By minimizing scale, induction heating boosts forging die life as much as 300 percent and prevents die sticking. Elimination of the scale problem has saved as much as 5 percent of the total weight of forgings, normally lost in the form of scale. No de-scaling is necessary. Since a minimum of scale is pounded into the forging, secondary machining and finishing costs are reduced. Absence of scale means a better finished product and fewer rejects. Induction heating, however, effects other striking economies, aside from those resulting from scale elimination.

MR. X: Speaking of savings, isn't the initial cost of induction heating equipment much higher than that of gas or oil-fired furnaces? Will these savings compensate for the higher equipment cost?

ENGINEER: Yes, Mr. X, Induction Heating equipment costs almost four times as much as a standard forging furnace. The money-saving advantages of induction heating more than counterbalance the equipment cost, however. Savings from scale reduction alone more than justify the greater investment. Induction heating operation costs are lower than for furnace heating since power is used only when parts are heated. No energy is wasted in warming up periods, and furnace maintenance costs are done away with. Expensive ventilating systems and mid-summer slowdowns are eliminated through the improved working conditions of induction heating. The induction heating unit acts as a forging output regulator. If forging machines should require unexpected maintenance, which necessitates their sudden shutdown, further heating of parts may be stopped without loss by simply pushing a button. In contrast to batch-type furnace heating methods, induction heating prevents the possibility of having a large number of heated parts accumulate and cool, or remain at high temperature too long in the furnace and take on additional scale while the forging machines are undergoing repair. Unskilled help can easily operate this equipment. Forging quality is improved through greater uniformity in heating results. Costs are repayed with profits by the savings effected by using induction heating for forging work.

MR. X: You have a pretty strong argument in favor of induction heating for forgings.

ENGINEER: Yes, THER-MONIC Induction Heating equipment has proven a very valuable tool to the forging and metal-working industry.

THERMONIC
INDUCTION HEATING CORP
NEW YORK

INDUCTION HEATING CORPORATION
389 LAFAYETTE ST. · NEW YORK 3, N. Y.
Largest Producers of Electronic Heat Treating Equipment for Forging
Brazing · Melting · Hardening · Annealing

hardness is greater with cold catalyzed finishing and with stoving than is the case with air-drying finishes.

Cold catalyzing is still in the experimental stage and requires extreme caution when used with the light metals. In principle, it consists of the addition of a catalyst to a suitable resin which effects a change in the resin from the B-stage (soluble in organic solvents) to a C-stage (insoluble and infusible). The main resins affected are the phenolics and the amino resins.

The phenolic and amino resins are very suitable for stoving finishes, and give extremely flexible surfaces. Stoving may be carried out in externally heated convection ovens or by the newer processes of gas or electric infra-red drying tunnels. (H. Ronald Fleck. *Light Metals,* Vol. 9, Aug. 1946, pp. 400-404.)

Pressing Operation in Powder Metallurgy

Condensed from "Metals Technology"

The process of pressing metal powders in a die may be divided into three phases: (1) packing, (2) elastic and plastic deformation, and (3) cold working with or without fragmentation. These steps do not necessarily follow each other in sequence; on the contrary, they usually overlap each other and one or the other may be absent under many conditions.

One of the most important factors in commercial pressing is the selection of the raw material itself. While it is a relatively simple matter to distinguish between the pressing behavior of copper and chromium powder, it is more difficult to differentiate between the behavior of two samples of iron powder which vary only slightly in composition and particle size.

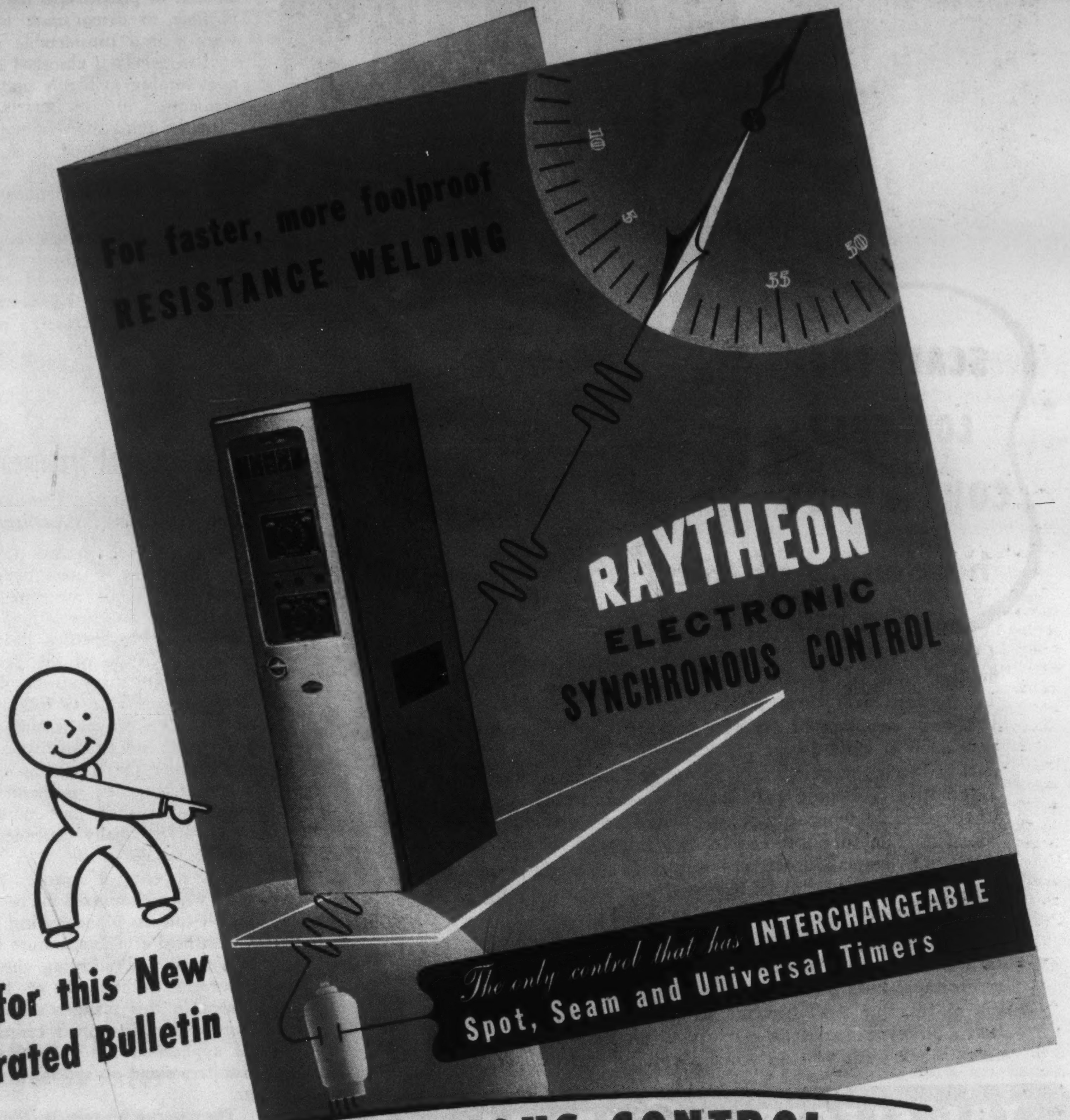
Important features for observation in powdered metal production are (1) the maintenance of sharp corners in handling green compacts, (2) good definition of shape details, (3) smooth surface, (4) ability of powder to flow into small openings in the die cavity, and (5) ability of green parts to resist deformation of cracking where intricate shapes are handled and where density gradients cannot be avoided.

Tests run on the speed of pressing showed that substantial pressures need be exerted only near the very end of the compression cycle, as too fast an entry at the start of the stroke may frequently blow metal from the die.

The method of feeding the metal powder into the die is an important feature if control of dimensions and properties is important. On large and intricate parts, the feeding is often done by hand. On smaller and simpler parts, the feeding is automatic. Regardless of whether the feeding is manual or mechanical, one of two methods is used—by bulk or by weight.

Experiments described show the importance of suitable particle-size distribution and the effect of budging in the first phase, called packing. The chemical and mechanical nature of the particle surfaces affect the process. The energy applied to the powder mass is largely absorbed by interparticle friction.

The second phase of powder pressing requires as a necessary condition a certain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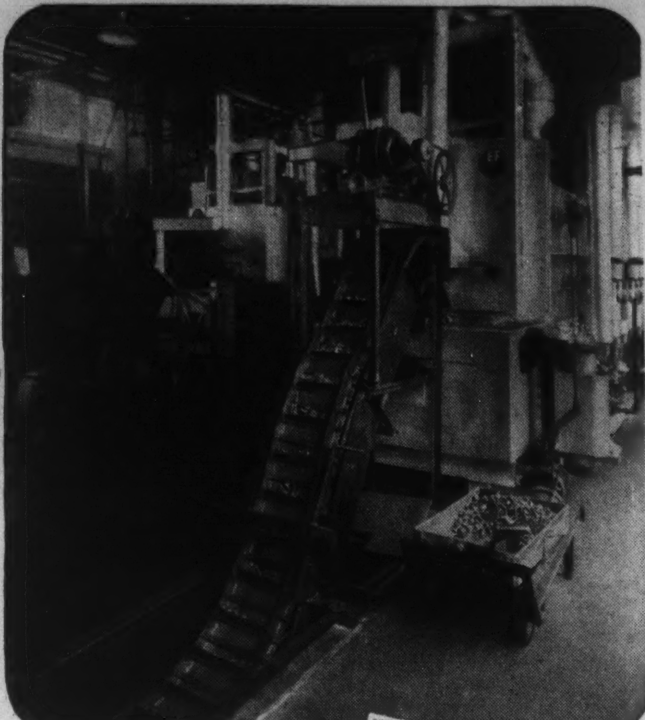

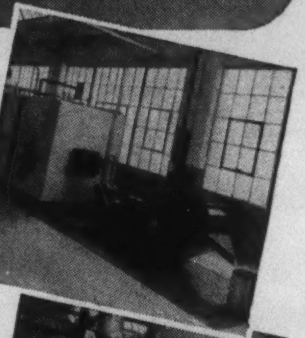

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amount of plasticity in the powder. It was possible to demonstrate by experimental work that a considerable amount of the applied energy is absorbed in die-wall friction, leading to highly undesirable density gradients.

In the third stage of pressing, which is characterized by the susceptibility of the powder particles to either cold working or fragmentation, high residual stress may be induced in the compact, leading to size changes and even failures after pressing, but they may be beneficial for the subsequent sintering operation. (R. P. Seelig & John Wulff. *Metals Technology,* Aug. 1946, Tech. Pub. No. 2044, 13 pp.)

Modern Heat Treatment of Steel

Condensed from "Transactions of the American Society for Mechanical Engineers"

Most of the processes involved in the heat treatment of steel depend upon the decomposition of austenite into one or more of its transformation products, and the physical properties produced depend upon the nature of the product formed.

In a recent investigation, Greninger and Troiano were able to follow the progress of austenite to martensite formation by tempering for a short time at a higher temperature the specimens quenched into a low-temperature isothermal bath. The results established that martensite formation was essentially dependent upon temperature alone.

Austempering is a process for heat treatment which eliminated the need for tempering. It consists of quenching the steel into a bath held at a temperature where bainite is formed and allowing the austenite to transform isothermally to bainite. Steels treated in this manner show considerable improvement in impact resistance; successful application has been reported in the heat treatment of springs, knives, chisels, etc.

The severity of quench required for complete hardening of a steel depends upon the reaction rate of that steel at the "nose" of the S-curve; but the construction of an S-curve for a given heat of steel is very time-consuming, so other methods of determining the hardenability of steels are used. Most popular is the end-quench hardenability test devised by Walter E. Jominy, which makes use of the fact that a heated steel bar, quenched only on the end by a jet of cold water, will have a very rapid cooling rate at the point of impingement of the water jet, and a continually decreasing cooling rate at increasing distances from the quenched end.

Correlation charts permit the rapid translation of hardenability data to cross-sectional hardness data for various tempering temperatures as well as the as-quenched values by using temperature curves. They also permit the rapid determination of hardness depth for incompletely hardened parts and the establishment of limiting size of a given steel for a particular quench when a minimum acceptable hardness has been decided upon. (E. R. Mertz. *Trans. Am. Soc. Mech. Engrs.,* Vol. 68, Aug. 1946, pp. 637-642.)

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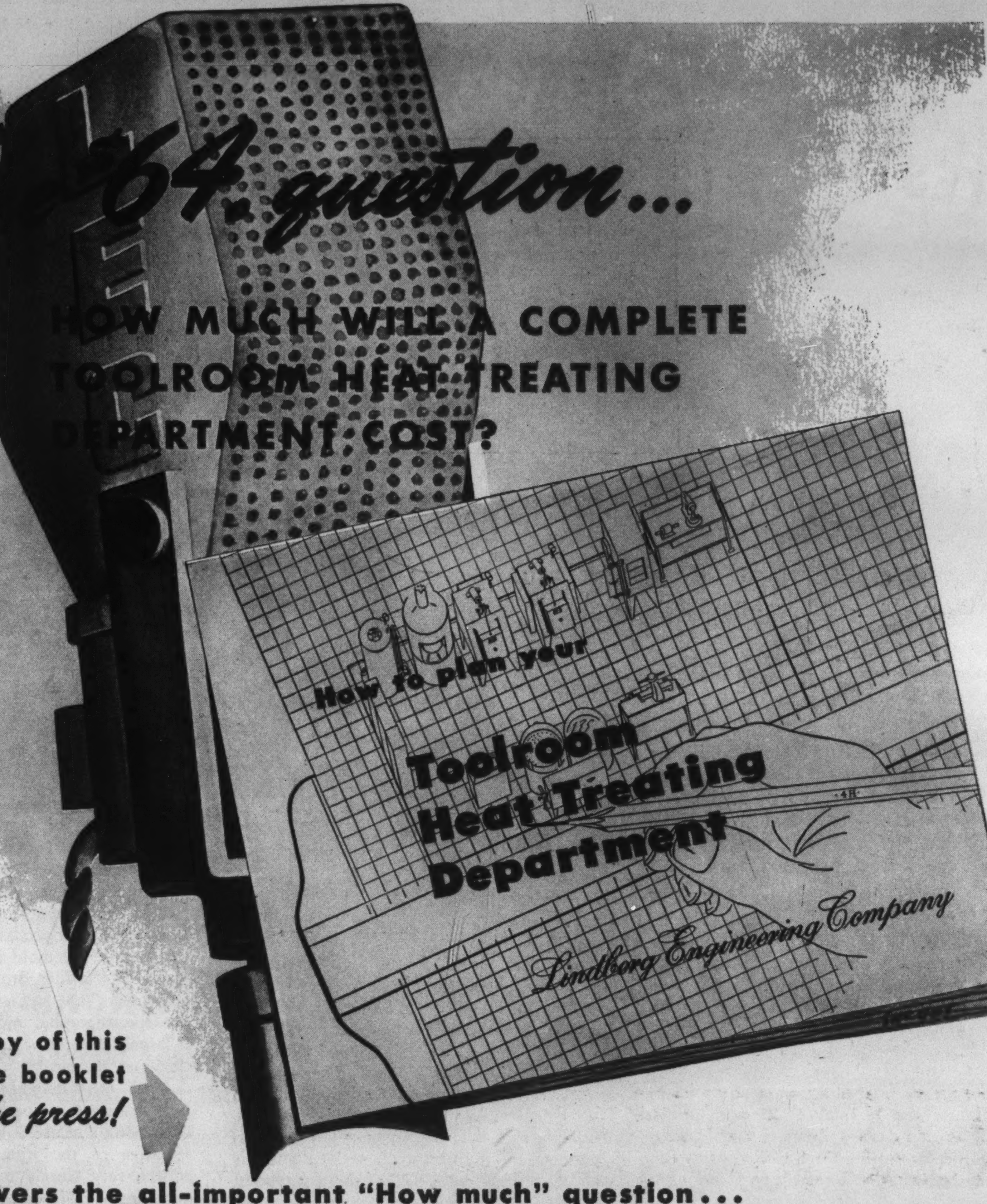

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Canadian Research Facilities

Condensed from "Canadian Metals & Metallurgical Industries"

Some aspects of the research and information services available to metals industries in Canada were discussed at the Conference on Industrial and Scientific Research, a feature of the 75th annual general meeting of the Canadian Manufacturers' Assn. Various papers described activities of the laboratories of the Bureau of Mines, Technical Information Service, Research and Development Branch of the Dept. of Reconstruction, and the Ontario Research Foundation.

There are three classes of work: routine analysis and commercial work, government-sponsored projects, and projects sponsored by private industry. Some of the work in progress in the laboratories of the Bureau of Mines includes research in melting and refining magnesium alloys; in their casting in sand and in permanent molds into billets and slabs; in the effect of alloying elements on magnesium; the properties of magnesium casting alloys and metal spraying on magnesium castings.

Preparations are under way for centrifugal and pressure die-casting of magnesium alloys. Other nonferrous alloys are being cast for extrusion, and the design of test bars for the sand casting of various copper alloys is being investigated. Heat-treating cycles and protective atmospheres for magnesium are being studied. Billets are being prepared for extrusion of nonferrous metals.

At the Ontario Research Foundation the greater part of the work is applied industrial research in which manufacturers request the development or improvement of a project, method or process. The staff consists of chemists, physicists, metallurgists and biologists. Problems are sometimes solved by a casual combination of minds, although only one mind may be specifically assigned to a given project.

Work of the Ontario Foundation falls into three categories: Long-term investigation, or industrial fellowships; short-term investigations; and routine work such as analysis and testing. There are 20 of the first type in progress. Patentable discoveries belong to the sponsor. The minimum cost of a long-term investigation is $6,000 per year.

The Foundation has a well-stocked scientific and technical library, it being observed that no investigation of any importance begins without consulting the library so that no time will be lost in retracing ground which has been covered in the past by others.

One of the objects of these various related research organizations is to develop Canada's natural products and make Canada supreme, the same as the Swiss as to watches, the Irish on linens and Sheffield in cutlery.

The Technical Information Service, as the name implies, answers all reasonable technical inquiries or directs the inquirer to the best source of information. About 90% of the inquiries are answered directly, the rest being directed to outside sources. Books may be sent on loan or free photostat copies of publications may be supplied. Government publications are furnished free, or the inquirer will be informed where he can secure copies. Sometimes an English summary or translation of an article in a foreig language is provided.

The object of these related agencies is t bridge the gap which now exists betwee scientific research and those who should b profiting by it. (*Can. Metals & Met. Ind.,* Vol. 9, July 1946, pp. 25-28, 43.)

Spectrographic Analysis of Cast Iro

Condensed from a Paper of the Iron and Steel Institute

The complexity of the iron spectrum necessitates the use of a spectrograph having a large dispersion, sufficient to ensure adequate resolution of the iron and alloying-element lines. The equipment now in use by the authors comprises a Hilger large quartz spectrograph, a Hilger non-recording photoelectric microphotometer, and a Judd Lewis spectrum comparator.

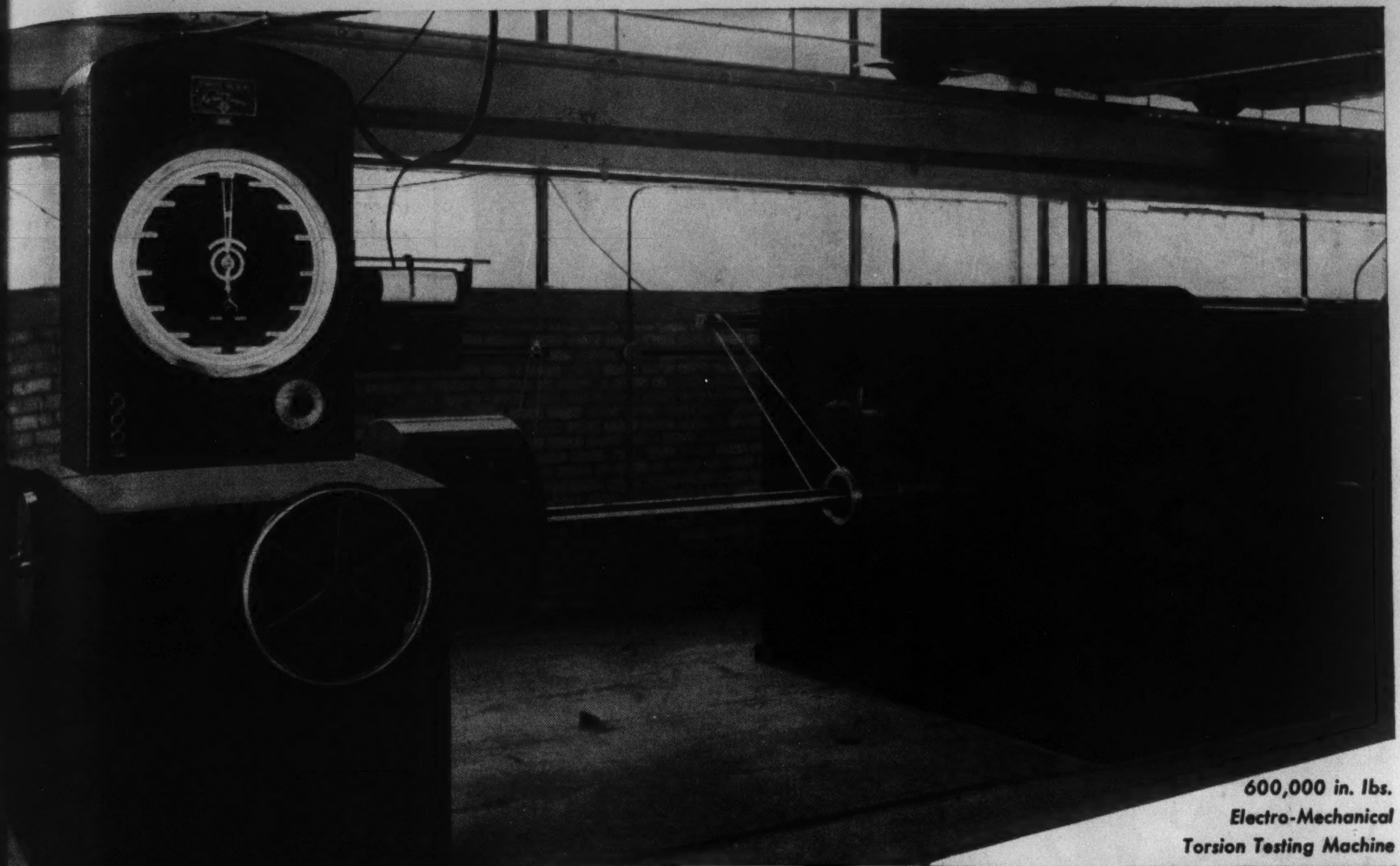
Special care was taken in siting the darkroom to obtain constant-temperature conditions at 67 F. within 1 deg. The amount of electrical power consumed by the complete spectrographic outfit is small, and the spark generator itself is rated at ¼ kva.

The taking of a sample for analysis is a major consideration in ensuring accuracy. The minute amount of volatilized metal consumed in the spark gap during an exposure (about 1 mg.) is much less than that used in the average chemical estimation. The ingot-type specimen is used for all molten-metal sampling, and with all the irons in current production the rate of cooling in the chill mold is sufficiently great to produce a white iron free from coarse graphite. The successful employment of the spectrographic method with cast iron is largely dependent upon the adoption of a chill-cast sample.

With the fine-grained chill-cast samples it is necessary to spark the sample in only one spot to secure a spectrum truly representative of the iron. It is necessary to adhere very closely to a fixed routine of operations. This demands an operator not having individual skill, but one well versed in physical principles and willing to observe strictly the established routine.

In the high-voltage spark method of excitation, the optimum gap width was found by experiment to be 2 mm., and the gap carefully adjusted to this width before each sample is sparked. An optical-projection method is used to position the upper graphite electrode, and the horizontal-flat surface of the ingot sample is then brought up to the sparking position and the gap tested by a feeler gage. A simple condensed-spark circuit working from an a.c., 15,000-v. source, with no added inductances, has been found to give the best excitation conditions for cast iron.

Two photographic emulsions which are most suitable for spectrographic work on irons are the Ilford Ordinary and the Kodak B.10. Both emulsions are supplied on thin glass plates, 2 x 10 in., upon which it is possible to record 15 spectra 2.5 mm. wide, comfortably spaced 0.5 mm. apart.



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The 8" diameter polishing disc is attached to a countershaft by a tapered sleeve. This tapered fit and long span between bearings assures smooth operation. The motor is ¼ h.p. single phase ball bearing, operating on 110 V., 60 Cycle AC current. Shipping weight, 80 lbs.

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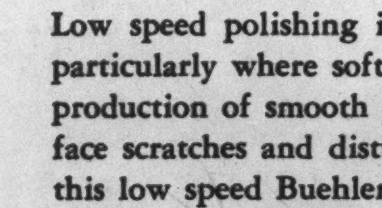

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The line pairs suitable for the analysis o iron are, for the most part, those which have been used for the spectrographic analysis of steel. Details are presented by th authors for a method of plate calibration based upon the relative intensities of a group of standard lines in the iron spectrum; the method has enabled a complete analysis of all major metals normally present in cast iron to be estimated accurately from one exposure.

Standard chemically-analyzed samples are used only for the establishment of "working graphs" from which the percentages of alloying elements in routine samples are read. (J. E. Hurst & R. V. Riley. Paper, *Iron & Steel Inst.*, June 1946, 12 pp.)

French Testing Machines

Condensed from "Institut Technique du Batiment et des Travaux Publics"

In testing machines the load may be imposed on the specimen by weights, springs or hydraulic systems. The use of weights is the simplest. Direct loading by weights is rarely possible except for very low loads. A lever system of some sort is generally employed.

The simplest hydraulic system using a threaded piston is found in most static testing machines built for loads over 15 tons. Almost unlimited loads may be obtained by hydraulic means. The only difficulty of these machines is the exact measurement of the applied load. The sole practical means is to multiply the oil pressure by the section of the piston, but this disregards the friction between the cylinder walls and the piston.

The use of hydraulic systems for repeated loading is more complicated. One field where hydraulic systems play an important role is in tri-directional stressing.

In spring systems the spring can be used simultaneously to stress and to measure the load. Spring loaded machines are often called "hard," since the spring is very rigid in comparison with the specimen. Weight systems by the same criterion are considered soft, while hydraulic systems are in between. Testing by very rapid (shock) loading is still in its infancy.

Means of measuring loads are discussed. With weights, the method of measurement is self-evident. In hydraulic systems, bourdon manometers are of prime importance where a precision better than 2% is not required. Spring manometers are frequently used, as are hydraulic dynamometers. With ring dynamometers, the deformation of the ring as the result of the load is measured with the aid of comparators.

Electric systems have found little favor, due to their fragility. The apparatus used for calibrating testing machines are in effect calibration dynamometers. There are various types of which the most prominent at present uses the plastic deformation of small copper cylinders under load.

Brief mention is made of the most recent innovations in the means of measuring deformation. (Robert L'Hermite. *Inst. Tech. Batiment Travaux Publics,* Circular, Series 1, No. 24, June 8, 1946, 20 pp.)

New Materials and Equipment

Duplex Milling Machine Designed for Small Parts

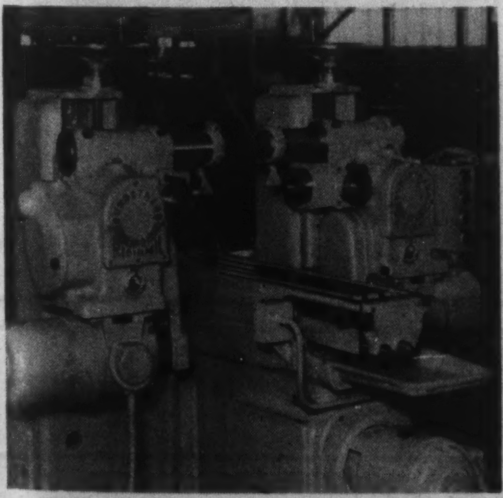
The *Sundstrand Machine Tool Co.*, Rockford, Ill., has designed and built a new small duplex type milling machine. This new machine mills two surfaces simultaneously on opposite ends of small work pieces such as lock, key, typewriter, gun, and business machine parts.

The machine has two horizontal opposed spindle heads which have independent vertical adjustment from 2 in. minimum to 13 in. maximum from top of table to center line of spindle. Thus, cuts on opposite ends of part can be made at different relative heights.

Spindle heads are of independent motor driven type. Either 1 or 1½ horsepower motors can be used. Heads are available in 2 speed ranges of 25 to 1200 rpm. or 50 to 2400 rpm. Speed changes are by pick-off gears, and each set of 2 gears provide 4 possible speed changes.

In order to increase the range of work that can be handled on this machine, the columns which carry the spindle heads are mounted and keyed to wing or base members. For small parts, the columns are set in the inner position. For light cuts on larger parts, the columns can be relocated in either an intermediate or outer position. Thus, each column has 3 fixed positions 1¾ in. apart which provide a total increased spread of 7 in. between spindle noses.

The machine has an 8 by 41½ in. long table. The maximum table feed stroke is 12 in., and rate of table feed is infinitely adjustable between ½ and 38 in. per min. Rapid traverse rate is 325 in. per min. Both feed and rapid traverse movements of the table are controlled hydraulically, mounted in the machine base. The length of feed and rapid traverse strokes are controlled by easily adjusted dogs mounted to the machine table.



Because of its two horizontal opposed spindle heads, cuts on opposite ends at different heights can be made.

Spray Washer is Adaptable to Cleaning and Drying

A flat conveyor type, spray washing machine, adaptable for cleaning and similar spray operations as well as for drying, has been announced by the *Optimus Equipment Co.*, 267 Church St., Matawan, N. J. The new machine will spray parts which may be handled either in baskets, on racks, or laid on the conveyor. Special parts can be positioned if necessary.

Alkaline, acid, solvent type, air drying, oil spray and similar operations can be handled. Any type of heating can be employed, and the machine can be designed with any of a number of different horizontal conveyors.

The machine has a long horizontal tunnel placed on top of a series of solution tanks. A continuous flat conveyor runs the length of the tunnel, carrying parts through a series of operations.

Solutions are forced on the parts through a battery of spray nozzles by means of a pump. The machine is self-contained, but it may be connected if desired to any other conveyor-moved operation.

● A special purpose two-stage machine for milling the bosses or cylinder head castings has been completed by *Hydraulic Machinery, Inc.*, 12825 Ford Rd., Dearborn, Mich. The machine is hydraulically operated and electrically controlled. Cycle of operation is: (1) Operator unloads and loads part in station away from work position; (2) while this is being done, milling head moves in, machining part, at work station; (3) milling head retracts; (4) the part the operator has just loaded moves into work station; and (5) repeat operation.

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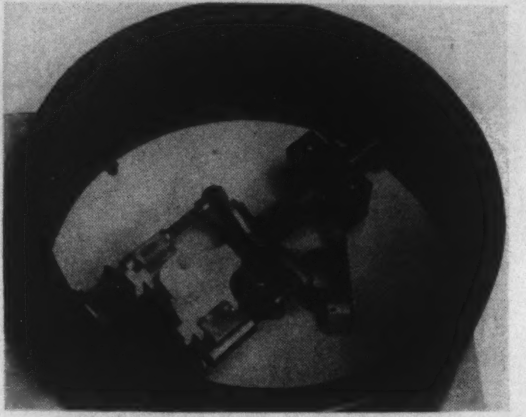
Melting and Casting Combined in Precision Casting Unit

Alexander Saunders & Co., 95 Bedford St., New York, has announced a new centrifugal casting machine and high frequency converter for casting nonferrous alloys and steels.

In the casting machine, designated Ecco, the metal is melted by high frequency in the casting crucible on the arm of the machine. When the metal has been brought to casting temperature, it is cast centrifugally into the burned out flask without further handling. This method replaces separate furnace melting of the metal and avoids transfer of the molten metal from a melting crucible to a distributing crucible.



Melting and centrifugal casting of metal are combined in this unit.

The flasks are burned out in a conventional gas fired oven located next to the casting unit. Temperature in the oven is controlled by a Brown "Milli-voltmeter" pyrometer. This consists of a single point indicator maintained contact controller operating a solenoid valve on the gas line.

The crucible used in the Ecco M34B casting machine has a capacity of approximately ¼ lb. of steel. Where larger capacity is desired, the Ecco M34C casting machine may be used. This machine operates on the same principle of high frequency melting of the metal in the casting crucible on the arm of the machine. The capacity of the crucible is increased approximately to 2 lb. of steel, and the casting arm may be used to carry flasks up to 5-in. dia. by 7-in. length.

Nickel-Base Alloys Resist Corrosion

The *Duriron Co.,* Dayton 1, Ohio, has announced the development of two new corrosion resistant metals, Chlorimet No. 2 and No. 3. They are high-strength nickel-base alloys.

Chlorimet No. 2 consists primarily of nickel and molybdenum. These two elements combine to give an alloy with good mechanical properties and resistance to the corrosive action of many acids, particularly hydrochloric in all concentrations and temperatures, including boiling. This alloy also can be used in sulfuric acids of 35 to 60% concentration at temperatures up to and including boiling. It is useful for sulfuric acid between 60 and 100%, at temperatures not to exceed 176 F. Good for hot sulfuric acid under reducing conditions, this alloy also handles wet hydrogen chloride gas.

Chlorimet No. 3 consists primarily of nickel, chromium, and molybdenum. Its similarity to Chlorimet No. 2 is that 50% of the molybdenum content has been replaced by chromium. The combination of these elements gives the alloy good mechanical properties and resistance to most acids, particularly under oxidizing conditions.

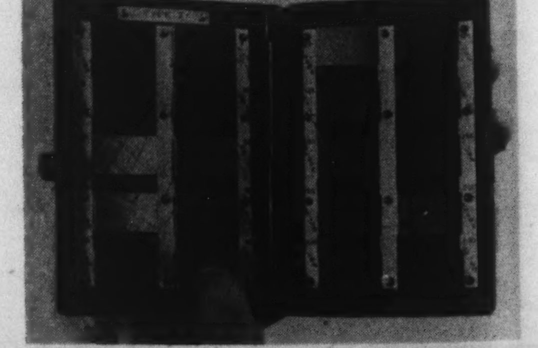
It safely handles hot sulfuric acid solutions in concentrations less than 35% at temperatures up to 176 F. It also withstands amonium chloride, sodium chloride, zinc chloride, nickel chloride; also hypochlorite bleaches (at room temperatures not over 105 F).

Surface Finish Standards Available in Handy Pocket Size

Conforming to the "preferred-number" series which the American Standards Association has recently adopted for designation of surface finish, a pocket set of standards has been developed by *University Machine Co. Div., Baird Associates,* Cambridge, Mass.

The set consists of 20 small blocks of stainless steel, each of which is machined to the surface finish specified for one of the "preferred-number" standards. The inspector checks the finish by drawing his fingernail across the specimen and across the standard. Small differences in surface finish are apparent by the "feel" of the surface.

The standard surfaces furnished in the University Type 7 Standard are: 2, 4, and 8 microinches polished; 16 and 32 microinches ground (straight and Blanchard); 63 microinches shaped, turned, and ground; 125 microinches shaped, turned, milled, and ground; 250 and 500 microinches shaped, turned, and ground.



These surface finish standards are accurately machined and checked by profilometers.

Recirculating Furnace Has Range of 350 to 1200 F

The *Eclipse Fuel Engineering Co.,* 778 S. Main St., Rockford, Ill., has announced improvements in its recirculating air draw furnaces. These units use a gas-fired atmospheric burner with a comparatively rich primary mixture, with enough air as a secondary supply to complete combustion. They are designed for heat treating in the temperature range of 350 to 1200 F.

The burners are protected against electric and gas failures by an electronic flame-failure unit. This prevents filling the work chamber or recirculating system with unburned gases.

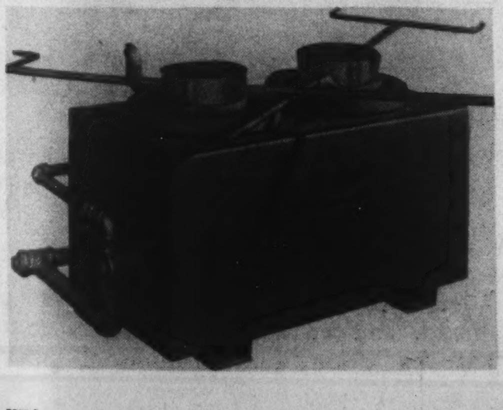
The outer construction consists of a casting on top and bottom, or steel plate with a sheet metal outer shell. This is lined with insulation good up to 1800 F. The inner liner is an 18:8 alloy sheet with an alloy casting to form the bottom of the work chamber on which the basket rests. The basket is also an 18:8 alloy.

There is a new panel control system. It is of the high-low type in which all wiring is accessible by removing the rear panel enclosure.

Aluminum Melting Furnace Designed for Medium Production Needs

A new aluminum melting furnace for medium production requirements has been announced by the *Kindt-Collins Co.,* 12651 Elmwood Ave., Cleveland, Ohio. This furnace has been designed for the moderate production needs of pattern shops, schools, smaller foundries and other plants, and as supplemental equipment for large foundries. The unit can be gas or oil fired.

With this equipment the aluminum can be melted in and poured directly from the heat-resisting alloy metal pot. This minimizes agitation and resultant porosity. The pots can withstand more than 100 heats when used with reasonable care. They are designed to keep gases away from the surface of the molten metal.



Where there is a need for aluminum melting furnaces for medium production, this equipment is applicable.

The furnaces are available in single units of 50-lb. capacity or double units of 100-lb. capacity, and can be equipped for the occasional melting of brass.

Machine Grinds Different Type Valves Simultaneously

Milwaukee Cock Grinding Machine Co., 2357-T North 29 St., Milwaukee, Wis., has announced two new six-spindle cock grinding machines designed to grind and lap larger sizes and a wider variety of types of tapered valve cocks. Sizes from 1/8-in. IPS to 1½-in. IPS, including those for steam, air, gases, liquids and railroad cut-out and angle cocks, are handled. They grind and lap up to 300 cocks per hr., depending upon the size.

This machine will grind up to six different types of valves at the same time.

The machines will grind up to six different types of valves simultaneously. Each spindle is separately controlled by an engagement clutch, permitting each spindle to be loaded individually. The valves while being ground are rotated in a true manner and the bodies are self-centering on the valves, thus insuring a perfectly ground valve seat.

Model B is provided with two-jaw chucks for grinding valves with flats on the stems. Model C is equipped with heat treated alloy steel collets for gripping round valve stems. Collets are available with grips up to 1-in. dia.

● A new type of drill-jig bushing has been introduced by *Hi-Shear Rivet Co.,* 1559 Sepulveda Blvd., Hermosa Beach, Calif. The bushing, called Anchor Bushing, consists of hardened steel bushing. The bushings are a formed steel anchor into which is pressed a Since the bushing can be spot-welded to supplied in standard drill sizes up to 3/8 in. require a heavy fixture, the weight of the completed tooling is ¼ or less the weight any flat or curved template and does not of ordinary drill-jig fixtures.

Longer
Life
for Your
LIQUID BATH
THERMOCOUPLES
with
GORDON
Vent-Type
Thermocouples

Thermocouples used in liquid baths such as cyanide and salts have previously worn out rather rapidly owing to the fact that gases apparently pass right through the protecting tube, collect inside, contaminate the thermocouple and shorten its life.

The new Gordon vent-type thermocouple eliminates this collection of gases by providing a vent through which they are allowed to escape. It is also possible to blow a small amount of air from a convenient air connection through the tube to remove these gases.

Thus, by reducing contamination, the life of the thermocouple is greatly increased—often two or three times—and makes its life comparable with that of the tube itself.

This new type of thermocouple, by extending both the life and accuracy of your liquid bath thermocouples, offers you a real saving. One-half of all Gordon thermocouples are now supplied with this vent. Send for full information and price list.

Gordon also offers a full line of thermocouples and accessories of all types

GORDON SERVICE

CLAUD S. GORDON CO.

Specialists for 32 Years in the Heat Treating and Temperature Control Field

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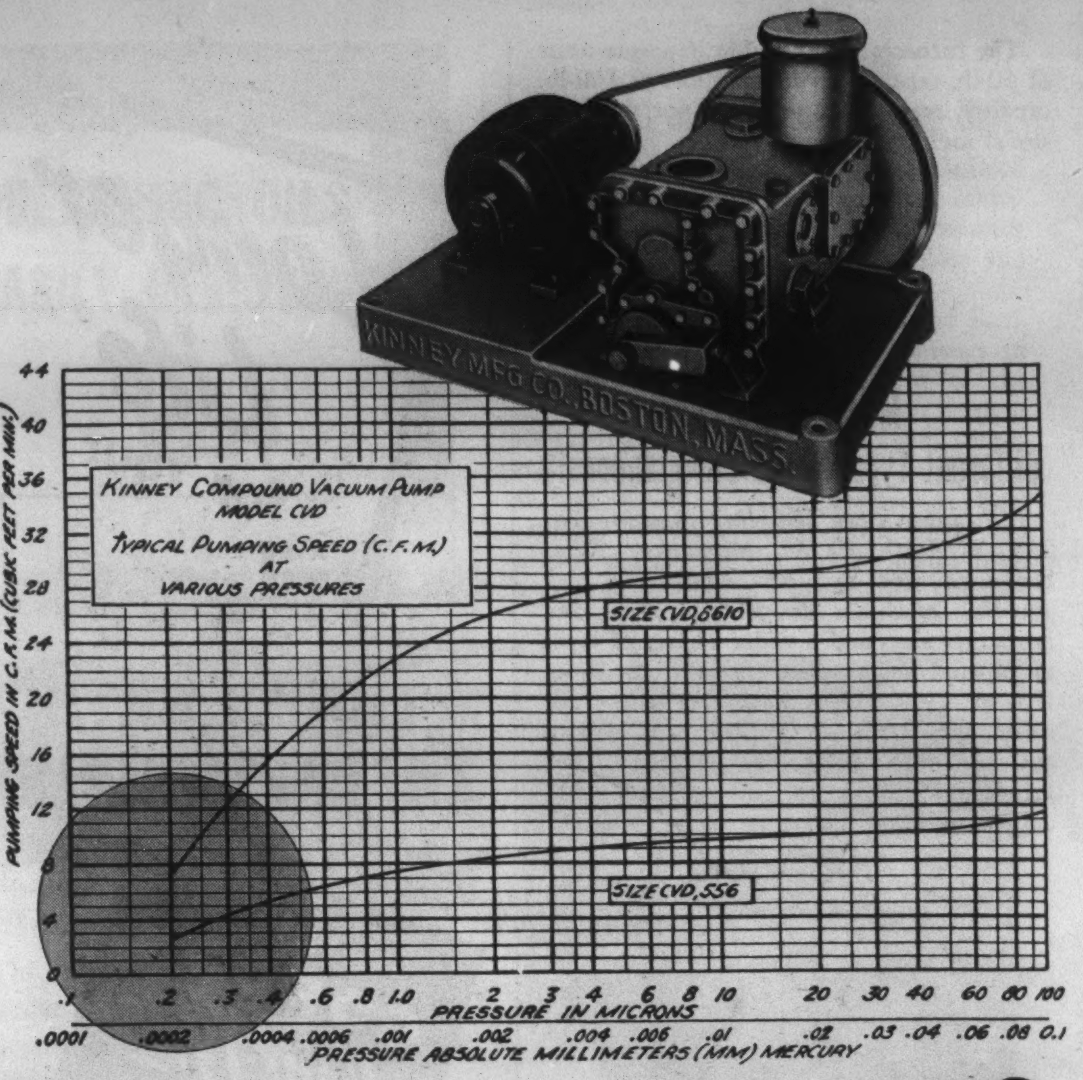

Produce **NOTHING**

-AT LOWER COST!

Fast pump-down to extremely low absolute pressures . . . to nearly *nothing* . . . makes the Kinney High Vacuum Pump invaluable for preliminary roughing, washing, and finishing stages in lamp and electronic tube manufacture.

1 **Lower final pressures and faster pump-down mean shorter production time.**

2 **Higher pumping speeds permit smaller pumps to do the work.**

3 **Smaller motors reduce power costs.**

4 **Automatic lubrication and oil sealing lengthen pump life and prevent re-expansion.**

Accepted as standard equipment in the production of incandescent lamps and electronic tubes, Kinney High Vacuum Pumps are serving dependably in countless other applications where low absolute pressures must be maintained. Kinney Single Stage Pumps produce low absolute pressures to 10 microns or less; Compound Pumps to 0.5 micron or less.

Write for Bulletin V45.

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WE ALSO MANUFACTURE LIQUID PUMPS, CLUTCHES AND BITUMINOUS DISTRIBUTORS

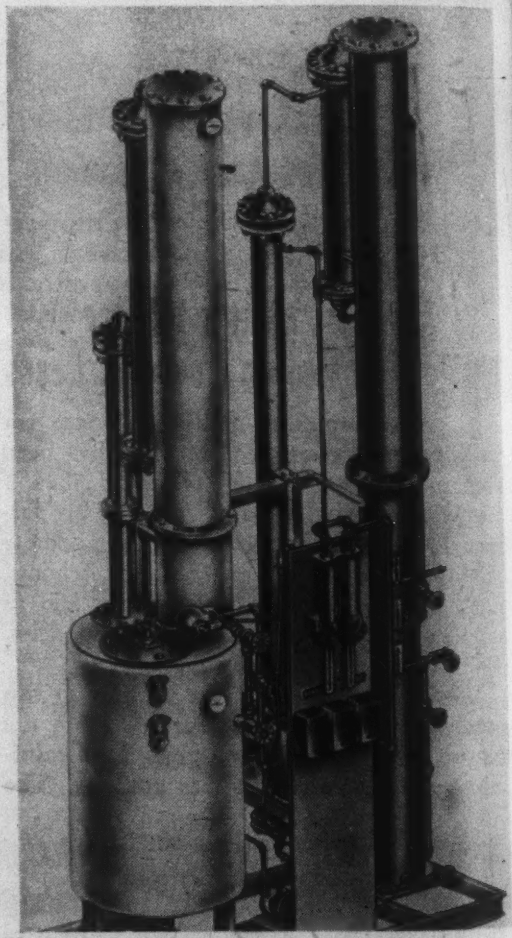
KINNEY
HIGH VACUUM PUMPS

Heat Treating Without Decarburization Possible With New Gas Producer

A new gas producing equipment providing a neutral, CO_2-free, dry, combusted gas for heat treating medium- and high-carbon steels without decarburization has been announced by the *Industrial Heating Div., General Electric Co.,* Schenectady, N. Y. The Neutralene gas atmosphere is suitable for bright annealing, clean hardening, and furnace brazing of medium- and high-carbon steels, hardening of high-speed steels, and sintering of high-carbon ferrous metals.

Differing from the conventional system of using an atmosphere gas converter plus a CO_2-removal equipment, this unit consists of a combined combustion chamber and reactivating tower, CO_2-absorbing tower, gas cooler, heat exchanger, and liquid cooler. For drying the gas, a refrigerated gas cooler and an activated alumina dryer are furnished.

The analysis of gas may be varied over a relatively wide range for specific applications. A typical mixture, suitable for heat treating, sintering, and brazing, consists of about 10.5% carbon monoxide, 15% hydrogen, 1.5% methane, and 73% nitrogen (dewpoint -40 F). Freedom from carbon dioxide and water vapor eliminates decarburizing action, and inclusion of carbon monoxide and a small amount of methane provides a slight carburizing tendency, overcoming any action of impurities which might enter the furnace atmosphere. Another analysis useful as an atmosphere for annealing medium- and high-carbon steels and brass in bell-type furnaces is 1 to 2%

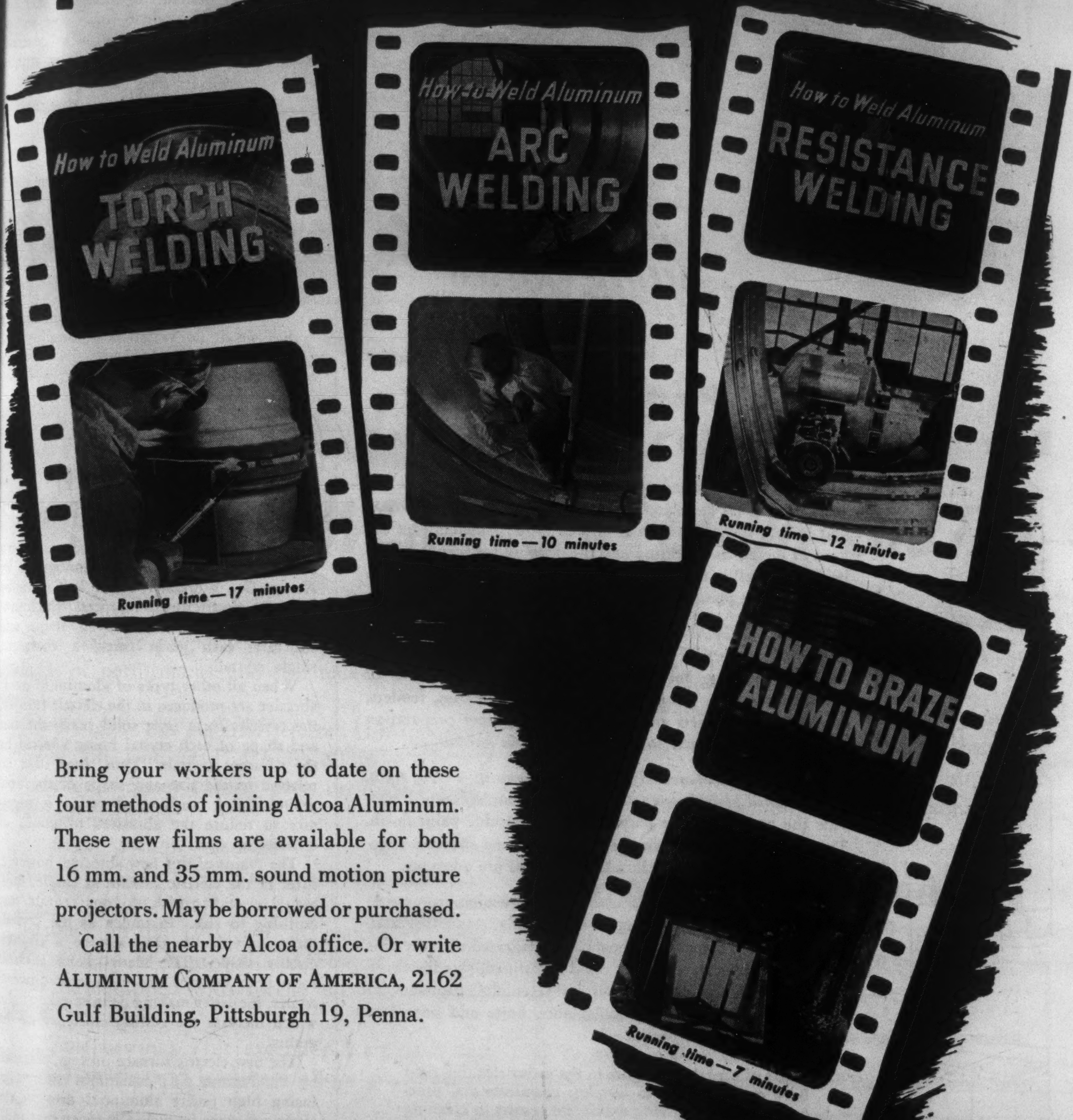


The combustion chamber of this convertor is built into and supplies heat to the boiler of the reactivating tower.

(Continued on page 1566)

They're NEW...

4 "HOW-TO-DO-IT [illegible] BY ALCOA

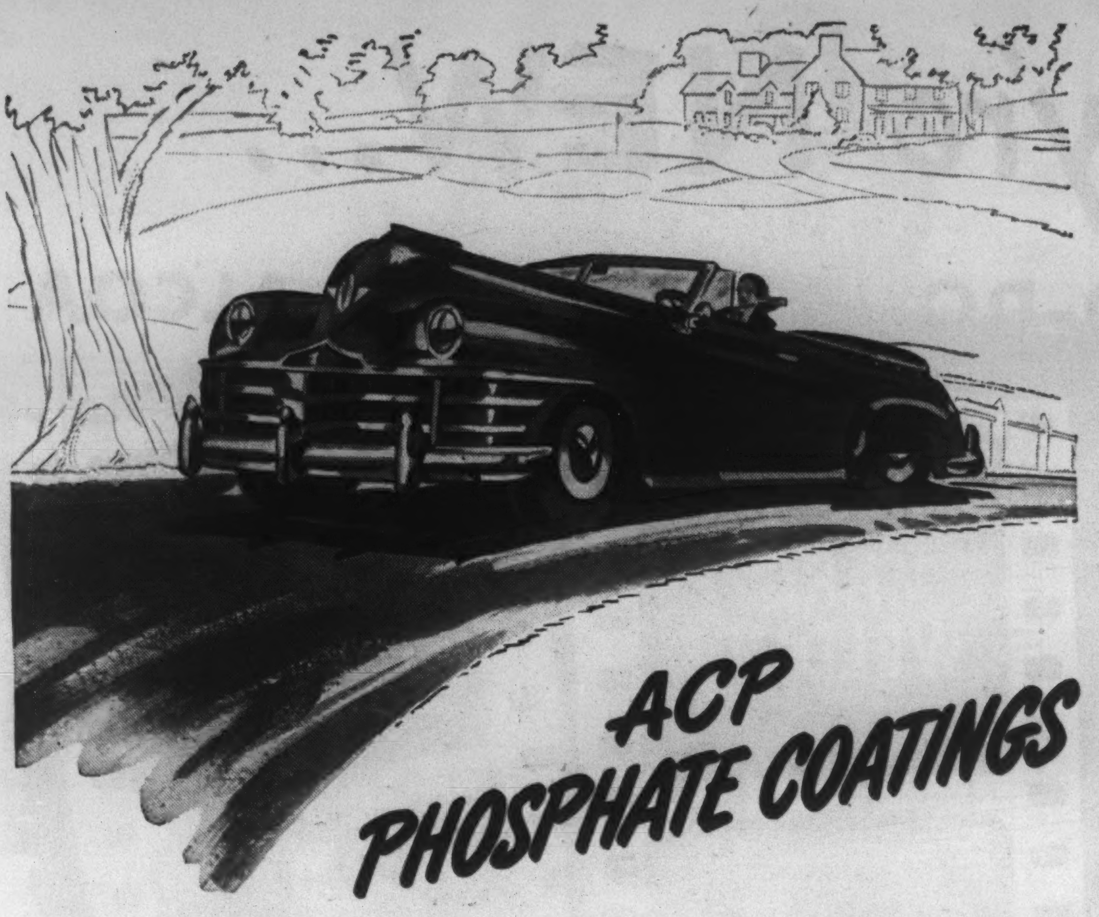

How to Weld Aluminum
TORCH WELDING
Running time—17 minutes
How to Weld Aluminum
ARC WELDING
Running time—10 minutes
How to Weld Aluminum
RESISTANCE WELDING
Running time—12 minutes
HOW TO BRAZE ALUMINUM
Running time—7 minutes

Bring your workers up to date on these four methods of joining Alcoa Aluminum. These new films are available for both 16 mm. and 35 mm. sound motion picture projectors. May be borrowed or purchased.

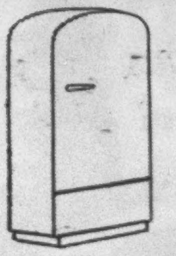
Call the nearby Alcoa office. Or write ALUMINUM COMPANY OF AMERICA, 2162 Gulf Building, Pittsburgh 19, Penna.

ALCOA ALUMINUM

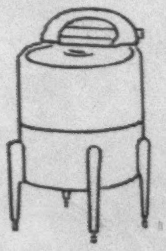
IN EVERY COMMERCIAL FORM



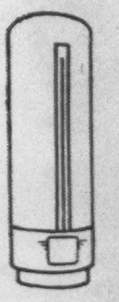
Positive Protection For Painted Metal Surfaces



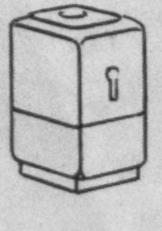
ACP phosphate coatings produce an excellent paint-bonding surface on metal parts and provide a foundation for a lustrous and lasting finish. There are various types depending on the kind of metal, its condition and the purpose for which it is to be used as well as the equipment facilities of the manufacturer. Some of these phosphate coatings are briefly described.



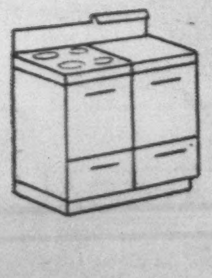
Cold SPRAY-GRANODINE in a short spray time forms a uniform, smooth, zinc phosphate coating—a superior base for lustrous, enduring paint finish. Cold Spray-Granodine is of special interest to fabricators of automobile bodies, fenders, refrigerators, cabinets and in general for proper preparation of sheet steel products for *durable, lustrous finishes.*



DURIDINE *simultaneously cleans and deposits a thin, tight, close-grained phosphate coating* on ferrous surfaces which provide the proper surface preparation for durable paint finish. The Duridine process is simple, economical and effective. Present spray washer installations of mild steel are adequate.



THERMOIL-GRANODINE used in an immersion process creates on steel an oil-absorbing, paint-bonding, crystalline coating of iron and manganese phosphate, integrated with the base metal. Treated surfaces, when oiled or painted, provide excellent protection against rust. Thermoil-Granodine furnishes excellent rust protection for tools, nuts, bolts and unpainted replacement machine parts.



Years of actual experience in the metal cleaning field have enabled ACP to develop chemicals and processes which are giving maximum results in cleaning and surface preparation for paint for varied types of metal and under varying conditions. ACP Technicians have had many years' experience in this field and will gladly consult with you and recommend the ACP products and processes which will most effectively and economically meet your requirements.

AMERICAN CHEMICAL PAINT CO.
AMBLER ACP PENNA.

carbon monoxide, 1 to 2% hydrogen, and 96 to 98% nitrogen (dewpoint −40 F).

Other features are long continuity of operation and uniform gas analysis. Periodic shutdowns, or changes of input air-gas ratio to burn out carbon, are unnecessary. All the gas reformed in the combustion chamber can be processed by the CO_2-absorbing tower; however, some or all of the untreated combusted gas can be used independently if desired. Because of these advantages, the Neutralene producing equipment lends itself to adaption as a "central" atmosphere gas producing plant to supply gas to multiple furnaces.

● A batch type furnace for the heat treating of aluminum alloys has been announced by *Bellevue Industrial Furnace Co.*, 2917 Bellevue, Detroit, Mich. It consists of atmospheric type burner mounted on the lower end of the duct which is used for recirculating the air back into the furnace. This method of heating holds temperature with little or no variation. Mounting the burner in the duct eliminates the necessity of an extra heating unit.

New Abrasive Made by Unique Electric Furnace Process

A new aluminum oxide product, known as 32 Alundum abrasive, is announced by *Norton Co.*, Worcester, Mass. It is made by a unique electric furnace process which produces grains of an improved shape and structure, each grain being a complete, single crystal.

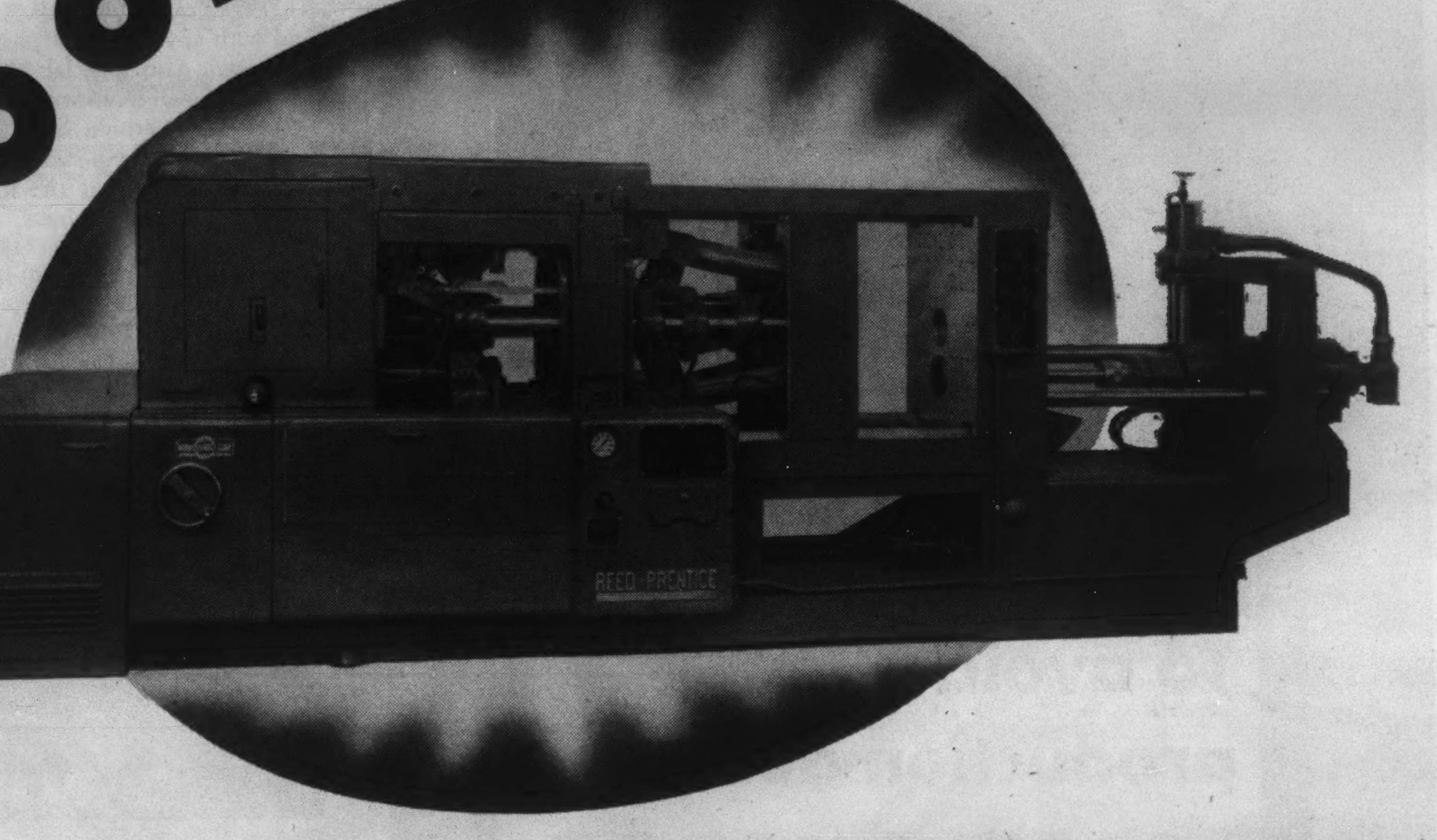
When all other types of aluminum oxide abrasive are produced in the electric furnace, the crystals form in a solid mass, the size and shape of each crystal being affected by the adjacent crystals. Thus, they bear no relation to the size and shape of the final grains, and a crushing operation is necessary to reduce the abrasives to grains of commercial sizes.

The grains of this new abrasive, however, form in the electric furnace as single, individual crystals which do not require any crushing to size. Inasmuch as the crystals form individually, they assume a chunky, nubbly shape. The many plane surfaces form both exterior and re-entrant dihedral angles, the latter making definite rake angles which increase the cutting efficiency of the grains.

The new electric furnace process, patented by the Norton Co., essentially consists of fusing high purity aluminous ores in the electric furnace in such a manner that individual crystals of commercial grain sizes are formed in a fluid matrix. The high-purity, chemically stable crystals are then separated from the matrix by a complicated, continuous chemical process. Without crushing, the naturally formed crystals are screened into standard grain sizes.

The chunky shape of the grains, plus more uniform bonding due to their high purity, is said to give long wheel life and freedom from frequent dressings.

LOOK HERE!



...for LOWER PRODUCTION COSTS!

The user of die cast parts today specifies the lloy that has the properties he requires to maintain andards of performance and still reduce production sts.

Whether the material selected is magnesium, uminum, tin, zinc, lead or brass alloys — you will ve time and money casting parts on Reed-Prentice e casting machines!

Light weight castings of magnesium and uminum (with high thermal and electrical conuctivity) or of brass, are being produced with speed nd accuracy on the 1½G and 3G model machines. or the casting of thin wall magnesium parts, the G may be equipped with special nitrogen accumutors, at extra cost.

Zinc castings (for exceptional strength and ughness) or tin and lead base alloys are precision cast on the 1½ model, which may be fitted with a quick mounting cold chamber attachment for magnesium, aluminum and brass alloys.

Reed-Prentice die casting machines present a definite opportunity to lower production costs and increase product output by keeping your supply of castings on schedule within your own plant.

ALSO MANUFACTURERS OF A COMPLETE LINE OF PLASTIC INJECTION MOLDING MACHINES

MAIL COUPON NOW FOR FULL INFORMATION

Reed-Prentice Corporation
Dept. P
Worcester 4, Massachusetts

Please send full information and literature on Reed-Prentice die casting machines as checked below:

..........Model #1½G ....Model #1½ ....Model #3G

NAME..........

ADDRESS..........

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ARMY E NAVY

DIE CASTING MACHINES
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To avoid production delays...

CAST SHAPES in one day!

with J-M Firecrete the Castable Refractory

WITH Firecrete on hand, you won't need to hold up production, waiting for special refractory shapes—*you* can cast them *in your own plant* and they're ready for work one day later!

Firecrete mixes and pours as easily as concrete, hardens quickly. Spalling and shrinkage due to drying and firing are negligible. Cast Firecrete in any shape you need, for furnace covers and bottoms, door linings, baffle tile, burner rings and other types of monolithic construction.

Three types: Standard, for temperatures to 2400° F.—H. T., for temperatures to 2800° F. —L.W. (lightweight, low conductivity), for temperatures to 2400° F. Write for Folder RC-13A, Johns-Manville, Box 290, New York 16, New York.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville FIRECRETE

The Standard in Castables

Tungsten Carbide Balls Available for Special Applications

Industrial Tectonics, Ann Arbor, Mic has developed manufacturing methods produce precision balls of tungsten carbi The balls can be manufactured in any si and with any desired degree of dimensio accuracy. Also, special sizes can be p duced in small quantities when required.

Tungsten carbide balls can be used burnishing and polishing operations, sin they will retain their size for a long peri of time. Their hardness, in combinatio with their corrosion resistance, makes tung sten carbide balls applicable for use

A display of the precision balls of tungst carbide.

check valves, particularly for pumpi equipment.

For special applications, such as in th case of tube drawing and bending equip ment, tungsten carbide balls can be fu nished with holes to permit attachment o wires and cables. The high compressi strength of tungsten carbide balls, in addi tion to their hardness, makes them suitabl also for special bearings and anti-frictio mountings.

New Adhesive Requires No Catalyst for Use

A new industrial adhesive, called N 4665, has been developed by *E. I. du Po de Nemours & Co.,* Wilmington, Del. is a liquid adhesive requiring no catalyst special preparation for use, and has a months' minimum stability with no t dency to gel inside of a year.

The adhesive can be used to join poro surfaces, nonporous surfaces, or nonpor to porous surfaces. The range of materi to which it adheres includes metals, gl wood, plastics, concrete, ceramics, fabr and vulcanized rubber.

The adhesive is particularly suita under conditions where a bond must maintained between substances hav widely differing coefficients of thermal

(Continued on page 1570)

NOW THAT TIMKEN IS SHARING ITS EXPERIENCE IN MACHINING TUBULAR PARTS . . .

—many new savings are being worked out!

For many years, The Timken Roller Bearing Company has been the world's largest user of alloy steel seamless tubing. Because basic parts of Timken Bearings are made from tubing, The Timken Company has spared no effort to (1) develop exceptional machining qualities in Seamless Tubing, and (2) to perfect the most practical machining techniques.

This experience has been supplemented by detailed job analysis and production planning for scores of manufacturers using Timken Alloy Steel Seamless Tubing. That is why today the Technical Staff of The Timken Company is recognized as the foremost authority on machining tubular parts.

Savings amounting to thousands of dollars have been made in many cases by elimination of drilling operations on bar stock, reduced boring, reduced scrap losses and shortened production cycles.

And the number of parts which can be made from tubing now has been increased by successful production in Timken mills of seamless tubing with 2 inch walls. Outside diameters vary all the way from ½ inch to 10½ inches with a wide range of wall thicknesses.

For the right tubing and the know how to make the most of it, contact our Technical Staff. Write today.

TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
Fine Alloy
STEEL AND SEAMLESS TUBES

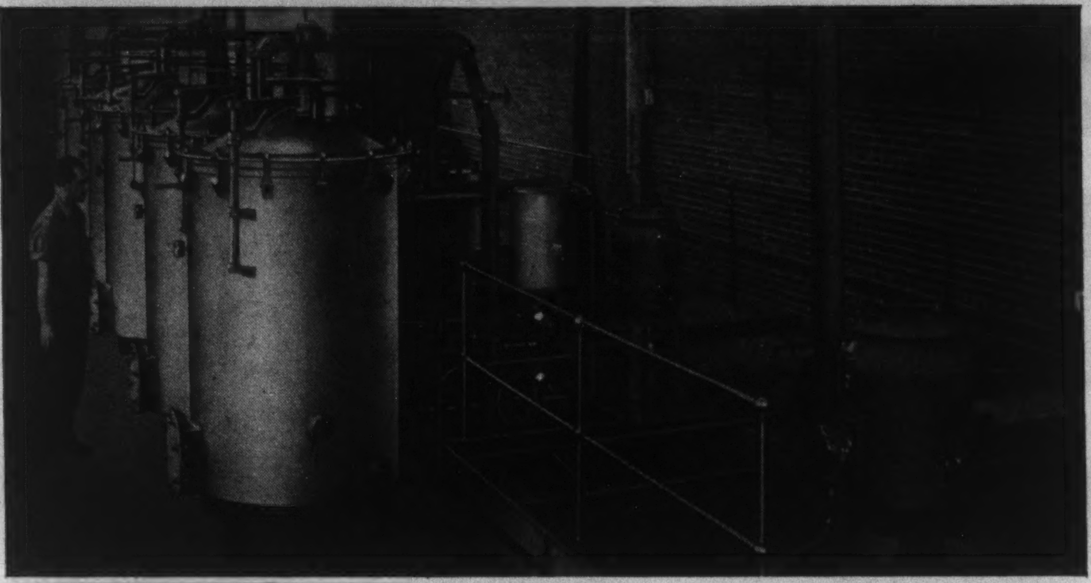
STEEL AND TUBE DIVISION
THE TIMKEN ROLLER BEARING COMPANY, CANTON 6, OHIO

SPECIALISTS in hot rolled and cold finished Alloy Steel Bars for forging and machining applications as well as a complete range of Stainless, Graphitic and Standard Tool Steel analyses. Also Alloy and Stainless Steel Seamless Tubing for mechanical and pressure tube applications.

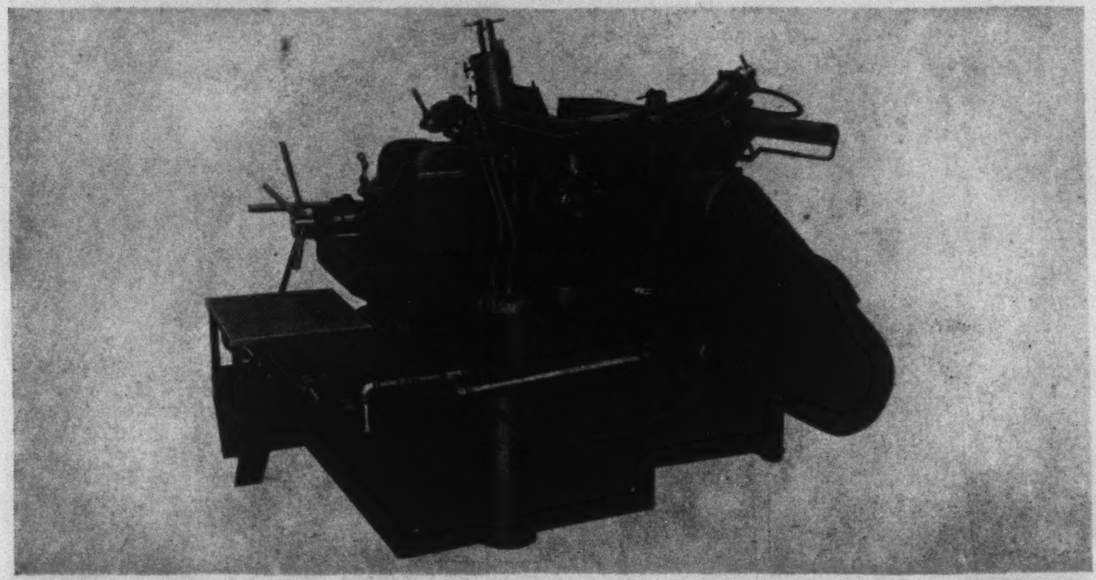
★ *YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH*

HOFFMAN FILTRATION

BRINGS YOU THESE IMPORTANT SAVINGS



EITHER IN CENTRAL SYSTEMS FOR MANY MACHINES



OR WITH SPECIALIZED FILTERS FOR INDIVIDUAL MACHINES

★ Hoffman Filtration increases production, lengthens life of machines, cutting tools and grinding wheels. One plant reports amortization of filter in 3 months.

★ Machines operate longer cycles without shutting down to clean out sumps. Pumps, last longer. Some models, with automatic sludge removal, permit nearly continuous operation.

★ Hoffman filtration supplemented by Hoffman coolant refrigeration where appropriate, enhances precision finish, aids in maintaining tolerances and reduces your rejects.

★ SEND FOR LITERATURE

U. S. HOFFMAN MACHINERY CORPORATION
223 Lamson St., Syracuse, N.Y.
COOLANT FILTERS • FILTRATION ENGINEERING SERVICE

pansion or dimensional changes caused fluctuations in humidity.

The adhesive can be applied, witho thinning, by brush, knife, roller coating, by dipping. The bonding technique depen upon the particular application. Th methods which can be used include cold wet bonding, thermoplastic bonding, th hot roll or hot press method, preheat bon ing, and oven bonding.

The cement is 27.5% solids. It is inso ble in water. Continued and prolonge immersion will result in some reductio in bond strength; however, original bon strength returns after removal from wate

The dried adhesive film is resistant t dilute alkalies and acids and to corrosive salt solutions. Also, it is not attacked b petroleum or coal tar solvents, lubricating oils, alcohols, ethyl glycol, or vegetabl oils. It is soluble in ketones or ester solvents.

Aging or continued heating will raise the melting point of the cement film; therefore, it has some thermosetting properties. The adhesive is supplied as an opaque tan-colored liquid drying to a brown adhesive film.

Electric Furnace Melts 900 Lb. Bronze Per Hour

Detroit Electric Furnace Div., Kuhlma Electric Co., Bay City, Mich., has announced a new type indirect arc rocking electric furnace which will melt up to 900 lb. o bronze or 500 lb. of cast iron per hr.

This model, known as the Type LFN, i rated at 150 kw. with 500 lb. nominal cold charge capacity, has rocking action which produces automatic stirring, and helps t insure metal of uniform quality. It is available with attached electrode brackets and mechanical automatic electrode control, or pedestal mounted electrode brackets with automatic hydraulic control. All melting factors, including melting time and composition, can be controlled by one man.

With this rocking electric furnace all melting factors can be controlled by one man.

The Industrial THERMAX in its Tenth Anniversary Model

IN 1936, ten years ago, Machlett introduced the Thermax—the first shockproof X-ray tube to combine in one unit radiographic, superficial and intermediate therapy applications. During the years since, it has made an outstanding contribution in these fields, giving the user a broadened field of techniques with minimum investment. The demand for tubes of this type or units of similar design offering even greater capacity, has been beyond our early expectations. As a result of this extensive experience, much additional knowledge was gained, which has enabled Machlett to completely redesign the tube. All the newest improvements have been incorporated without changing the external dimensions, and thus the tube can be used as a replacement in your present equipment.

The same small-sized housing is retained, rotatable through 360°. Strength has been increased at vital points. The new features increase the ruggedness and improve the function of the mechanical and electric internal structures.

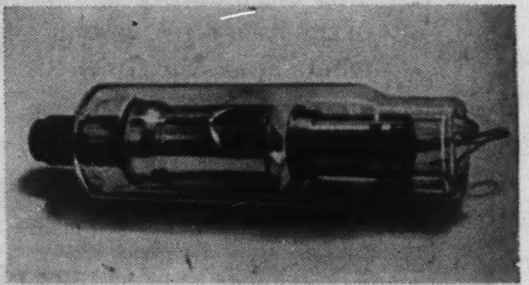
COOLING: Heat dissipation is substantially increased: Two models: water-cooled and oil-cooled. Latter now features a new system of supplying the oil in a highly efficient jet discharge. Metal in cooling system is corrosion-proof super-nickel.

INSERT: Redesigned for more efficient operation. Closed hood with beryllium window surrounds target; space within tube is field-free, minimizing wall bombardment and stem radiation.

SHIELD: Ray-proofing by a heavy copper hood. A lead-loaded bakelite shield insures greater electrical stability and inhibits internal scattering.

Full details of this cutstanding contribution to an important and growing field will be sent on request. Write Machlett Laboratories, Inc., Springdale, Connecticut.

150 PKV Industrial Thermax
20° target angle, available with single focus B spot, either water-cooled or forced-air-cooled.



The new, improved Industrial Thermax Insert

MACHLETT

APPLIES TO INDUSTRIAL USES
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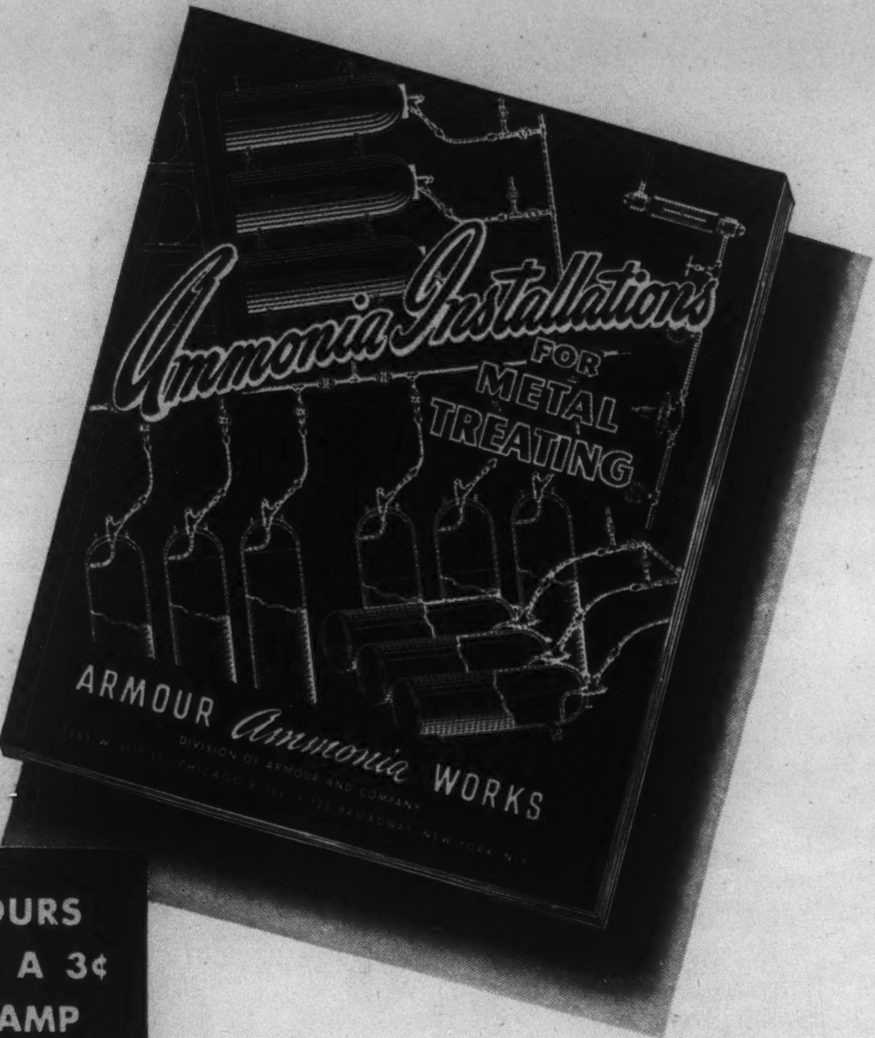
This 20-page Book!

Latest and most complete information on . . .



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"Ammonia Installations for metal treating"

This new book describes and illustrates in detail ammonia supply installations for metal treating.

This engineering booklet is based upon the wide experience of the Armour Ammonia Division's Technical Service Department. This department is always available to help you with your problems.

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Please send me FREE, your 20-page Book, "Ammonia Installations for Metal Treating."

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Instrument Checks Concentricity of Machined Parts

A new instrument for concentric checking, internal and external, on parts products having varying diameters has be designed by *Swanson Tool & Machi Products, Inc.,* 814 E. 8th St., Erie, Pa. Th device, known as the V-Liner, determin the proper center line heights required f any combination of diameters involved i a work piece. This is accomplished by turning a properly compensated screw whic raises the vertically adjustable V-block o the instrument.

The unit consists of two V-blocks mounte on solid members which are held in correc alignment by cylindrical rods. These aligning rods are pressed into the first V-block member and permit the second V-block member with elevating V-block to move a desired.

Its use insures a quick and positive check of the concentricity of internal and external diameters. This instrument determines the concentricity of shafts of varying bores, counterbores, and outside diameters. It provides a means for finish inspection of precision cylindrical parts. It also may be used for positioning and holding cylindrical parts on light milling, drilling, and surface grinding operations, and for checking distortions in parts after heat treating.

Concentricity instrument being used b grinding machine operator at point of production.

Speed Changes Without Stopping Spindle Possible on Spinning Lathe

A new metal spinning lathe has been announced by *Ermac Co.,* 5531 S. Vermont, Los Angeles 37. There are several safety features incorporated in the equipment, including a new lock, adjustable tool rest and a positive lock, rotary cam tail stock. The tool rest has a serrated, clutch type lock which prevents slipping and possible injury.

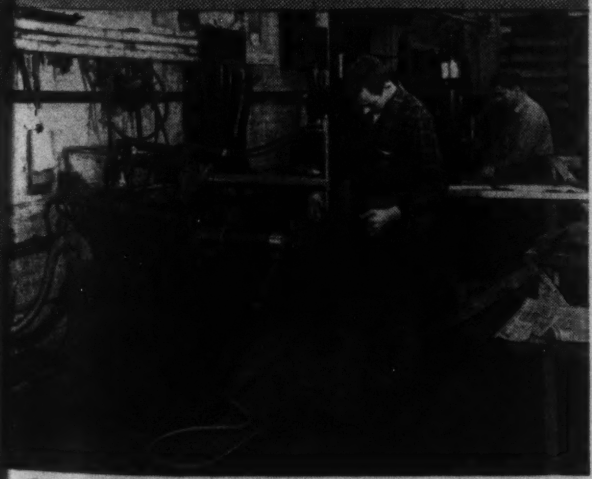
A 2-speed, 5-hp. motor, with 4-speed drive gives eight spindle speeds, ranging from a high of 1730 to a low of 205 rpm. Changes can be made from low to high speed, or high to low without stopping the spindle. High speeds are 1730, 930, 555, and 420 rpm. Low speeds run 850, 460, 270, and 205 rpm.

When Production Planning Sheet Metal Goods REMEMBER..

Federal Welders Raise Standards of Metal Fabrication... In Small Shop or Large Plant

For production welding of freeze boxes or furnaces, stoves or store fixtures, all types, all sizes.

Another production line application of Federal Rocker Arm Spot Welders.



One of a line of Federals in a large scale job shop making "anything" from sheet metal.

●

The business of making things from metal has come a long way since the days when everything from rainspouts to refrigerator liners was roll-seamed and soldered, not too many at a time, by craftsmen known (with all due respect) as "Tin Knockers". Today Federal Spot Welders play a big role in making Metal Fabricators out of such craftsmen.

In the smallest shops . . . the largest plant . . . Federal Spot Welders are speeding and improving fabrication of tremendous tonnages of metal. Variety of production is from small "tack on" jobs, accomplished with amazing speed, to assembly of full-size cabinets, lockers, boxes or what have you. Cuts in costs and "ups" in production are the rewards in each application. Try it on YOUR fabrication.

FOR SPECIAL DELIVERY

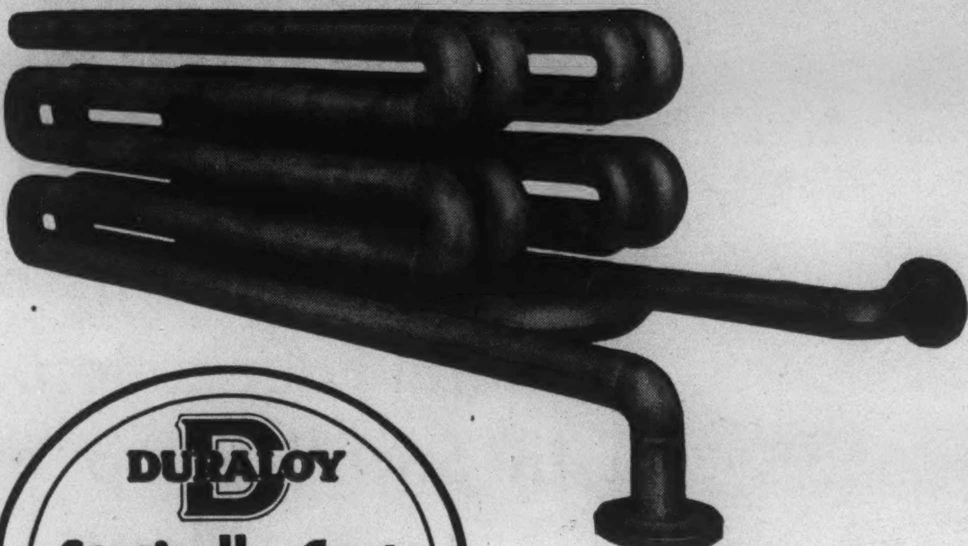
Current production permits early shipments on these models PA 1 Press Type Welders —Rocker Arm Spot Welders Subject to Prior Order.

THE Federal MACHINE AND WELDER CO.

SUBSIDIARIES
Sommer and Adams Co., Cleveland—SPECIAL HIGH PRECISION MACHINES
The Warren City Mfg. Co., Warren—WARCO PRESSES and PRESS BRAKES

200 DANA ST., WARREN, OHIO

A 2000 pound Pressure-Tight High Alloy Casting Assembly



DURALOY
Statically Cast Return Bends

welded to—

DURASPUN
Centrifugally Cast Tubes

This is the "coil" of a special heat exchanger alloyed and cast for a large company in the Rocky Mountain area. It's an excellent example of the kind of work our metallurgists and foundrymen are capable of turning out.

Backed by 25 years' experience with high alloy static castings and 16 years with centrifugal castings, we are in a position to produce any chrome-iron or chrome-nickel casting within the range of our electric furnace capacity—namely, about 4 tons for any one pour. We have an X-ray testing machine. We can finish the casting to any degree desired.

Write us about your problem. Send us drawings for a quotation.

THE DURALOY COMPANY

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METAL GOODS CORP.: St. Louis • Houston • Dallas • Tulsa • New Orleans • Kansas City

12-DU-1

Alkali Cleaner Does Not Tarnish Active Metals

Enthone, Inc., 442 Elm St., New Haven, Conn., has developed a new alkali cleaner called Enthone Brass Cleaner. It will degrease brass, copper, nickel, silver, tin, lead, steel and magnesium without attack. In cleaning aluminum it has a mild etching action. This cleaner can be used for soak cleaning as well as electrolytic cleaning. When used electrolytically, its cleaning action is faster. Steel can be cleaned either anodically or cathodically. Nonferrous metals are cleaned cathodically.

The cleaner has application in the plating room to clean metals before the plating process and particularly before bright plating. It is also suitable for cleaning brass, lead, steel and other metals before painting or lacquering, and for barrel and tumble cleaning.

The cleaner gives a pH solution between 11 and 12, has stable surface active materials and buffered alkali balance. No strong caustic is present to burn the operator's skin.

The same company has also developed an emulsifiable solvent cleaner, EC-75. This product is designed to remove oil, buffing compounds and other organic dirt, as well as solid dirt, from all types of metals including active metals such as zinc, aluminum, brass and nickel silver. One of the characteristics of this product is that it will not harm alkali cleaners when it is dragged into them, and it is claimed to actually increase the cleaning ability of alkali cleaners.

The cleaner is used undiluted. The material is a penetrating solvent to replace naphtha, kerosene and chlorinated solvents and, in addition, it has high detergency and emulsifiability.

Spray Booth Coatings Ease Waste Paint Problem

Two companies have recently announced spray booth coatings to facilitate the removal of overspray.

The *Du Bois Co.,* Cincinnati 3, is marketing its compound under the name of Filmite. It is a fluid compound which can be sprayed or painted on paint booth walls and forms a skin over a nonhardening base. After the overspray has accumulated, the skin with its adhering overspray can be peeled from the walls and the soft, water soluble undercoat may either be washed away, or left as a base for a new coat of Filmite. The coating is neither inflammable, nor is it corrosive or toxic.

The *Harris Soap Div., Hygrade Food Products Corp.,* Buffalo 6, N. Y., is producing a coating under the name Boothcote. The compound is nonflammable and can be applied by spray gun or brush. It does not dry out and, therefore, remains effective over a long period of time. It comes ready-mixed and is applicable with all types of finishes including varnish, lacquer, enamel, plastic paints, and metallized paints.

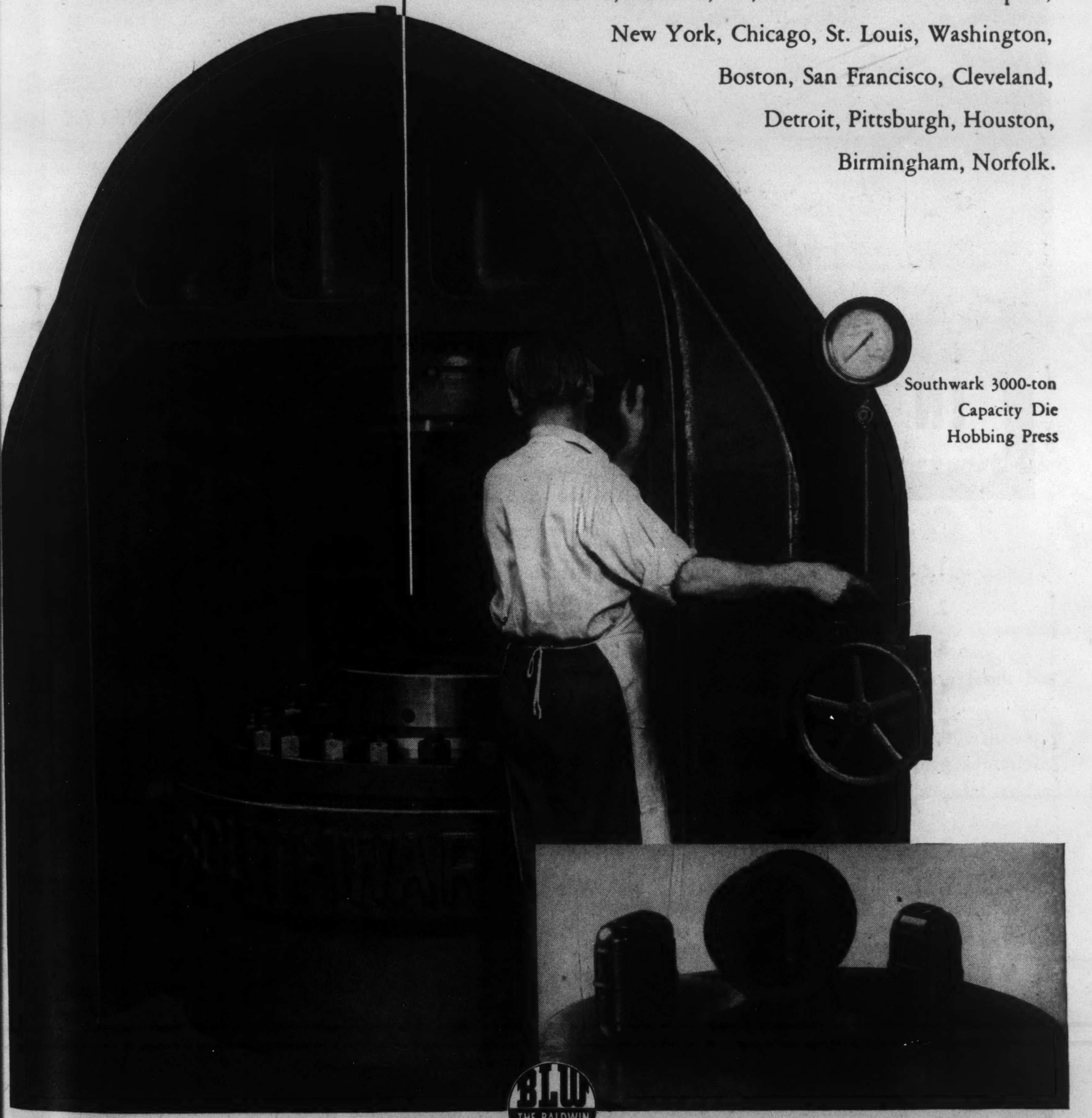
BALDWIN

PRECISION

DIE HOBBING

PRESSES

INTEGRAL construction for maximum strength and rigidity. Parallelism of anvils is maintained in operation. Long stroke permits deep hobbing. Valve arrangement gives accurate precise control of ram speed through two handwheels; ram may be stopped at any point. Design and construction proven in scores of individual installations. Ask for Bulletin 224, which illustrates the types available in capacities from 100 to 3000 tons. The Baldwin Locomotive Works, Phila. 42, Pa., U. S. A. Offices: Philadelphia, New York, Chicago, St. Louis, Washington, Boston, San Francisco, Cleveland, Detroit, Pittsburgh, Houston, Birmingham, Norfolk.



Southwark 3000-ton
Capacity Die
Hobbing Press

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BALDWIN HYDRAULIC PRESSES

"ROCKWELL"
HARDNESS TESTER
Made Only by Wilson
ROCKWELL
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IMPROVEMENTS IN LATEST MODELS

1. Elevating Screw now made of Stainless Steel
2. Ball Chuck now made of Stainless Steel
3. Plunger Rod Base now made of Stainless Steel
4. Stem of Plunger Rod now Hardened and Ground
5. Testing Head and Dial now Totally Enclosed
6. Penetrator Clamp Screw now an Automatic Clamp
7. All Operation Controls now Bunched Together
8. Dial of Gauge now has Zerominder Scale for Speed
9. Finish now Greatly Improved over War Times

Most used testers of our make lack all of these 9 improvements. All except those made recently lack many of them.

ACCO
TRADE MARK
WILSON MECHANICAL INSTRUMENT CO., INC.
AN ASSOCIATE COMPANY OF AMERICAN CHAIN & CABLE COMPANY, INC
365 CONCORD AVE., NEW YORK 54, N. Y.

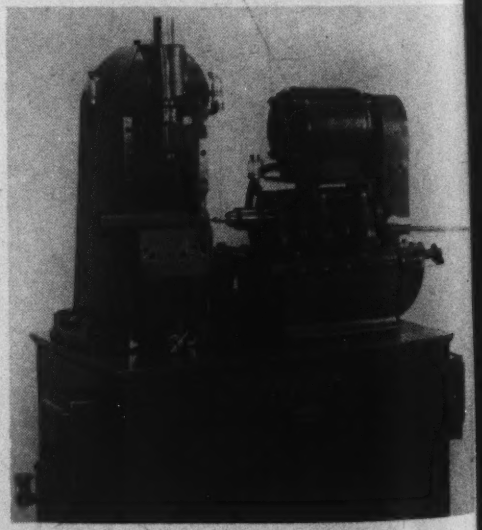
● A new revolving tip "live" lathe ce with the same dimensions as standard s centers has been announced by *E. H. V derwall Co.,* 440 Golden Gate Ave., Francisco. A hardened steel center spi revolves within the steel taper shank. Th is taken by a replaceable steel ball a thrust plate. The thrust end of the spin is slotted and spring tempered to yi slightly under load, thus automatically co pensating for expansion due to heating the work.

Center Drilling Machine Has Automatic Centering and Clamping

A center drilling machine with automa centering and clamping is now being pr duced by *Detroit Tap & Tool Co.,* 84 Butler Ave., Detroit 11. It is a high pr duction machine and uses a single lever control all operations, including automa positioning, clamping, and feeding the dri

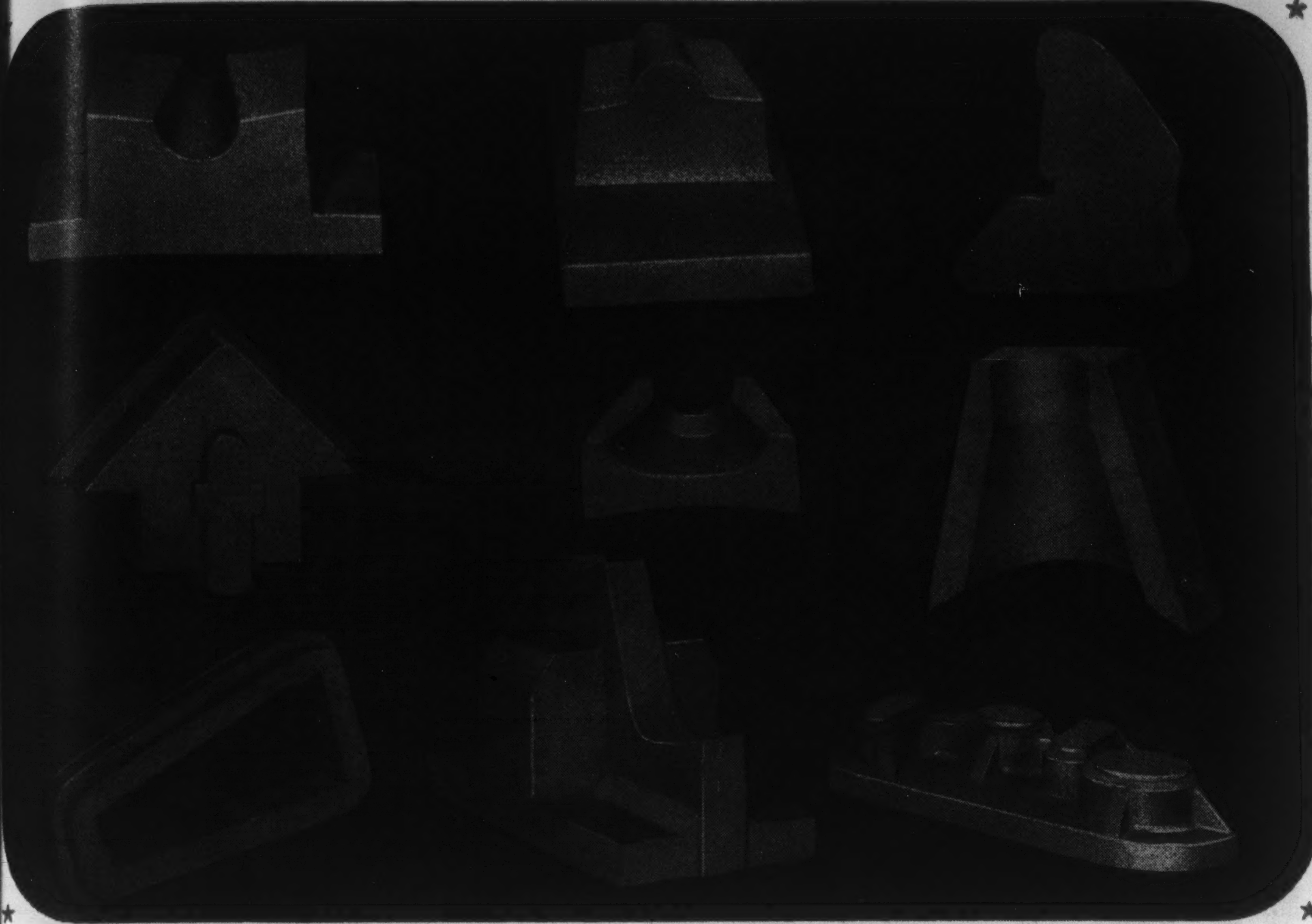
The machine will handle a wide ran of shapes and sizes. Concentric centers m be drilled in round, square, etc., stock ran ing from ⅛- to 2⅜-in. outside dia.

The self-centering vise automatical clamps the work in concentric alignme with the centering drill. The vise is act ated by an hydraulic cylinder, controlled b a three-way valve actuated by an extensio of the drill head feed lever. Two rac mating with a fixed pinion transmit oppos vertical motion of equal amounts to th upper and lower V-block jaws of the vis One of the racks is integral with the hy draulic cylinder plunger rod. True vertic alignment is maintained by mounting eac of the jaws of the vise on hardened an ground adjustable ways.



Minimum of skill is required to operat this center drilling machine.

The drill head is of the cartridge type with precision ball bearings, and travels on hardened and ground adjustable ball bearing ways. The drill has three speeds, 1250, 2400, or 4200 rpm., obtained through a V-belt step pulley drive from the spindle drive motor.



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Gives you full details on FCC Air Hardening, Oil Hardening and other Cast-To-Shape Tool Steel Specialties capable of saving you time and money.

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W&D 566

FCC Cast-To-Shape, the modern method of tool and die making, is effecting important savings of time, trouble and money for an increasing number of manufacturers.

Even very intricate shapes can now be cast successfully within an eighth inch of finished size. This means that you buy less steel at the start and reduce machining costs substantially.

Tools which could not be made by conventional methods except in sections can often be fabricated from FCC Cast-To-Shape blanks in a single piece.

In many instances performance of the tool is better than can be obtained by fabrication from bar stock or forgings.

Particulars are available through Allegheny Ludlum representatives; or write for the booklet today.

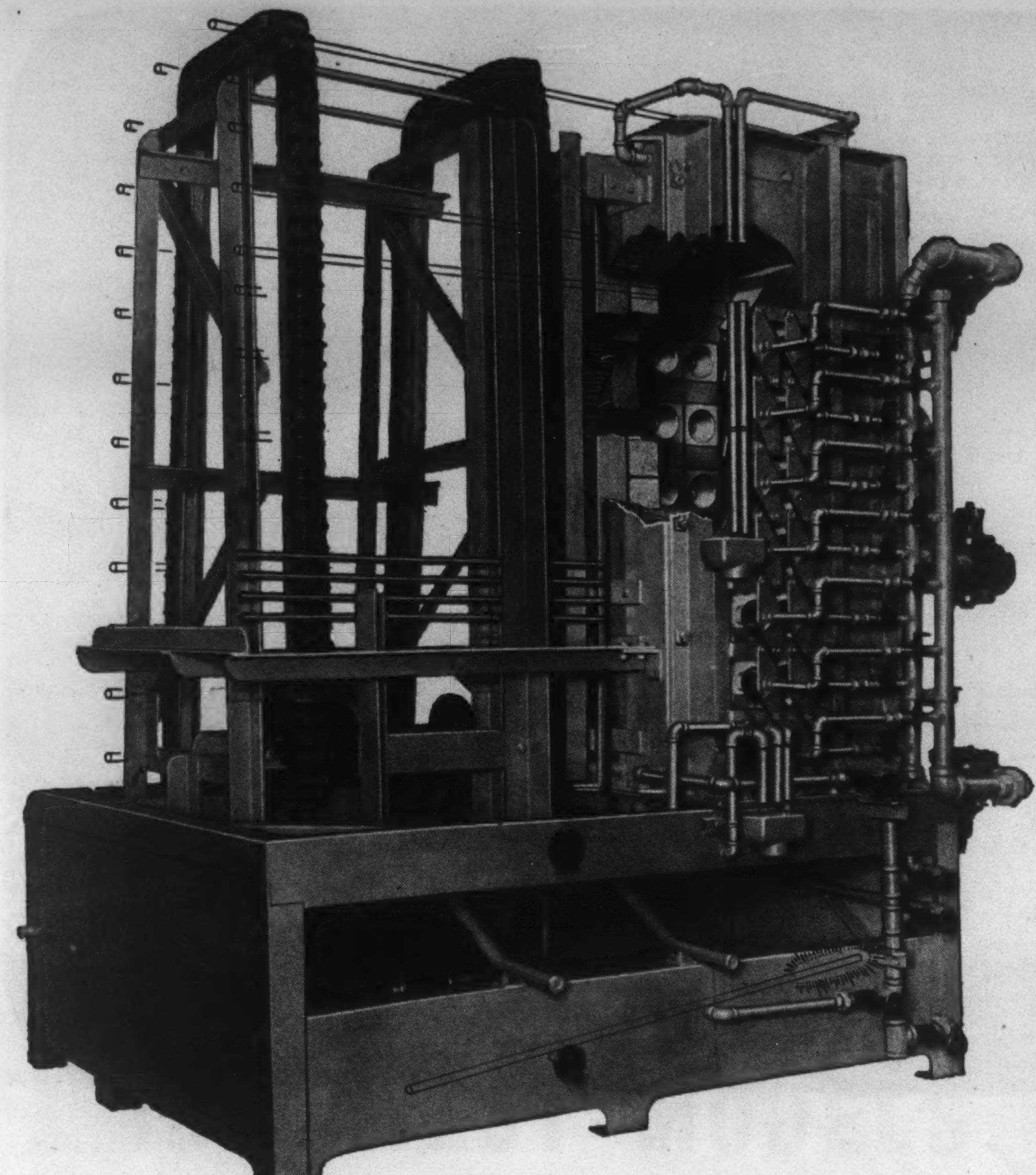
AL

ALLEGHENY LUDLUM

STEEL CORPORATION

Forging and Casting Division

DETROIT 20, MICHIGAN



Bars are loaded on side and discharged to forge operator. Bar-ends pass through high temperature slot where they are uniformly heated by Duradiant Burners.*

FORGING DIE LIFE INCREASED 300%

...by Selas* Production-Line Heating

Bar ends are now automatically brought to forging temperatures—right on the production line—to cut costs and improve metallurgical results. Discharging from the forge furnace at production line rate of one every seven seconds, the elapsed time from cold bar to completed forging is so short that there is hardly time for scale to form.

In addition to increased die life, users report low fuel gas and power costs of approximately one-tenth of a cent per bar.

Production line techniques can be applied to most heat processes to increase production, improve results and reduce costs. Selas experience in this field can be of valuable assistance.

*TRADE MARKS REGISTERED U. S. PATENT OFFICE

IMPROVED HEAT PROCESSING

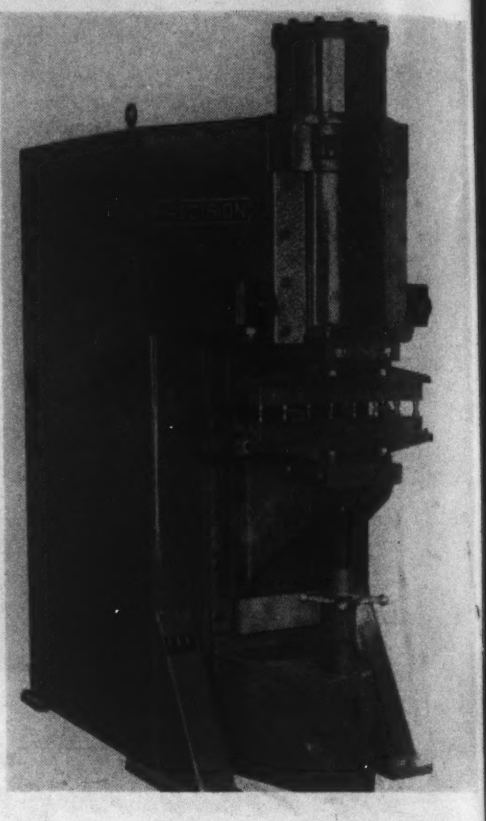
SELAS CORPORATION OF AMERICA

PHILA. 34, PA.

Press-Type Welder Used for Precision Work

The *Precision Welder & Machine* Co., 138 E. McMicken St., Cincinnati 10, has announced a new air vertical action spot and projection welder. Known as Type AVA, these press-type welders are made in four standard sizes covering the range from 30 Kva. to 500 Kva. and pressure to a maximum of 18,000 lb.

The equipment has a honed brass air cylinder with cushion and universal connection to the ram. The fabricated steel frame has the overhang arm integral with it for accuracy and rigidity. The gibs are adjustable for wear, and full length lubrication is provided.



This press-type resistance welder can be adapted for spot or projection welding.

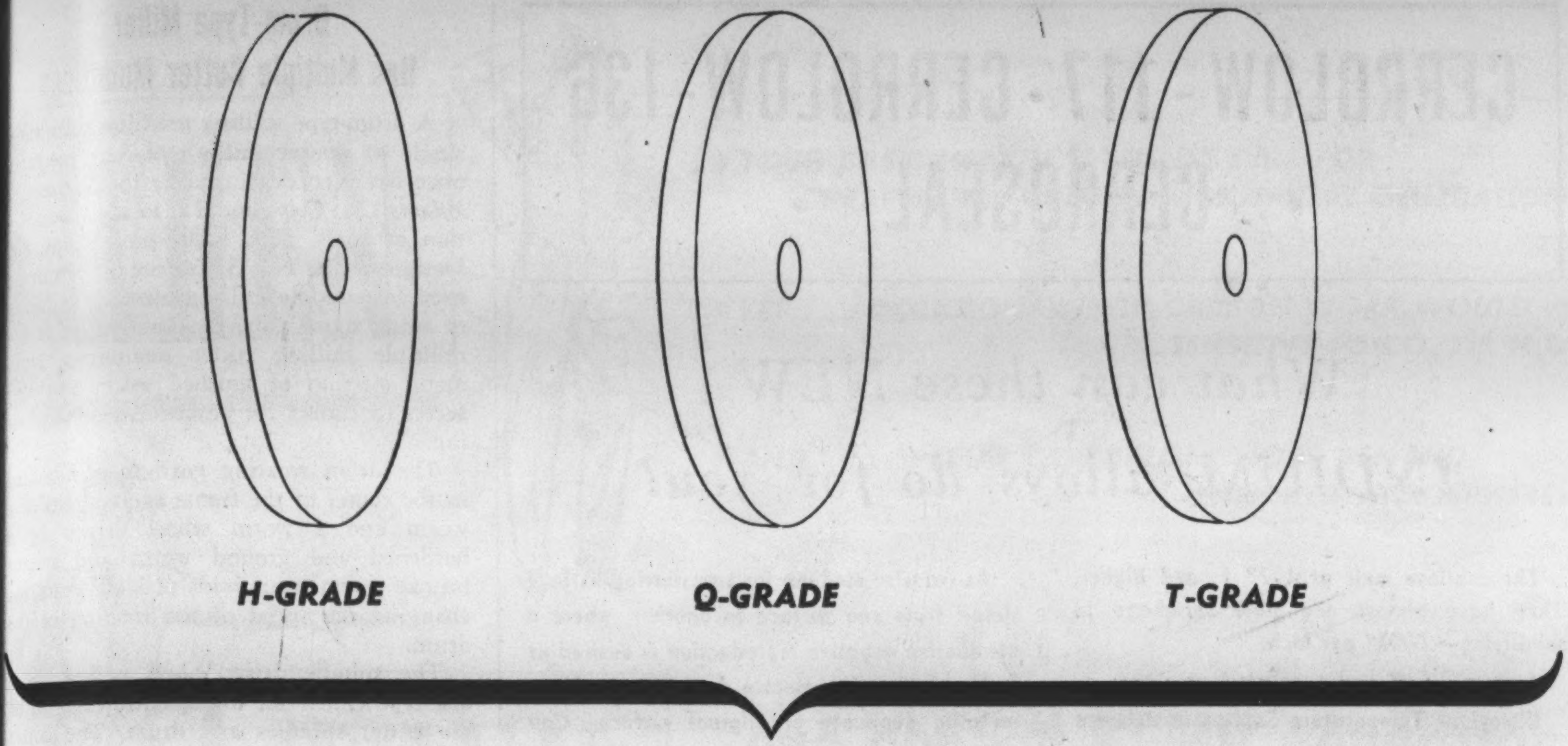
All press-type welders can be equipped for spot or projection welding.

Blind-Type Rivets Available in Monel

The *Cherry Rivet Co.*, 231 Winston St., Los Angeles 13, has announced that Monel rivets have been added to their line of cherry blind rivets. They are made in two standard types, self-plugging and pull-through hollow.

The self-plugging type are said to have stress values and vibration resistance comparable to solid rivets. During installation, the inner stem expands the rivet shank to fill the hole tightly, forms the blind head, and remains locked in the rivet shank by compression and high friction coefficient.

The pull-through hollow type clinches the mating sheets and expands during installation to fill the hole.



There's more to grinding grades than the A, B, C's

The A, B, C's which appear as identification on a grinding wheel help simplify proper grade selection. By clearly showing relative hardness, they make your choice quicker, easier...aid in assuring the right grade for the job. That's one reason wheels by CARBORUNDUM are plainly marked. But, there's more to it than the old chestnut, "the softer the metal, the harder the wheel." It's not that easy.

You realize, for instance, that wheel speed itself affects grinding action. The same grade reacts differently at various speeds. The condition of the machine and the amount of vibration can make a difference. Desired finish...required tolerance must be considered. Coolant conditions vary. The actual type of operation—snagging, surfacing, internal grinding or whatever it is—influences practical selection.

Yes—there are many important factors to check before you can be sure of the right grade designation for the job.

That's why we suggest consulting your CARBORUNDUM salesman or our distributor's representative. These men work throughout the year on a wide variety of grinding problems. They are familiar with grinding in production... in tool rooms...wherever it is used. They have practical knowledge and experience to help you pick exactly the wheel you need for the job.

Assisting these representatives in the field are our Abrasive Engineers. Specialized experts, they are equipped to analyze uncommon problems...recommend sound solutions. And, here in our modern laboratories are scientists and technicians who are working on the application of abrasive developments to changing grinding practices.

This *three way route* to better grinding is easy to use. No obligations are incurred. Merely talk "grinding" with a CARBORUNDUM representative. He'll be glad to assist you. The Carborundum Company, Niagara Falls, N. Y.

A good rule for good grinding . . . **CALL IN**

CARBORUNDUM

TRADE MARK

ABRASIVE WHEELS
Silicon Carbide
Aluminum Oxide
Diamond

COATED AND BONDED ABRASIVES
Paper and Cloth Combinations
Sheets, Rolls, Discs
Cylinder Hones
Sticks, Stones & Rubs
Specialties

ABRASIVE GRAINS AND COMPOUNDS
for:
Polishing
Lapping
Pressure Blasting
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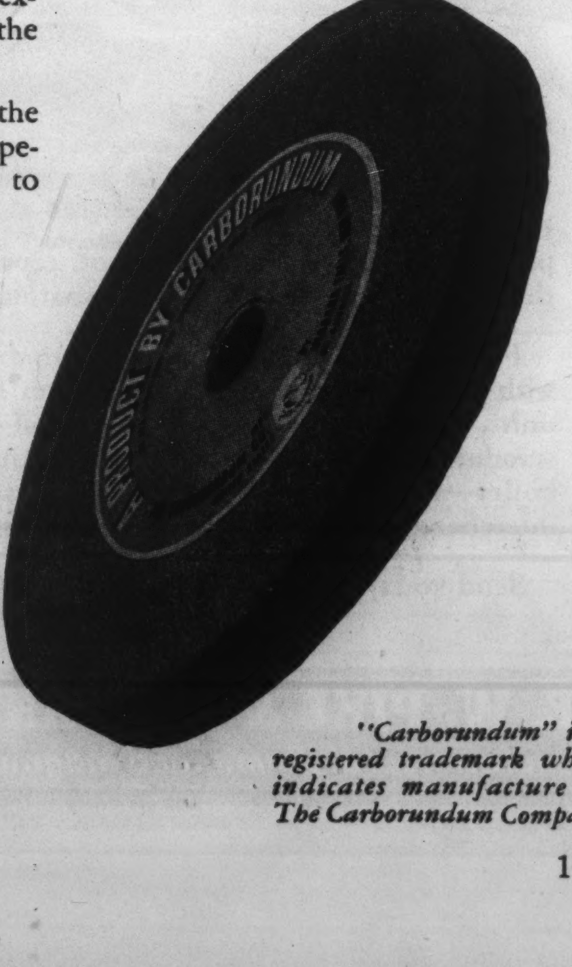

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What can these NEW INDIUM alloys do for you?

These alloys melt at 117° F. and higher. They have almost negligible shrinkage in solidifying—.0002" per inch.

Among actual and suggested uses are:

Ultra-Low Temperature Solders in delicate special instruments.

Low-Temperature Fuses — for Diathermy, Electrical and Refrigeration Applications.

Mechanical Safety Devices for protecting delicate machinery, etc., against operation at harmful elevated temperatures and for controlling processing.

As transfer medium for transferring surface detail from one surface to another, where a conductive negative reproduction is desired as a foundation for electro forming to obtain metallic duplicate of original surface. Can be cast or sprayed against human tissues or other fragile materials without harm.

Joining of laboratory glassware for vacuum or pressure seal.

Many other applications. Describe your problem. Maybe we can give you the answer.

CERRO DE PASCO COPPER CORPORATION
40 WALL STREET NEW YORK 5, N. Y.

IF THERE IS A FLAW
"FLASH-O-LENS"
WILL FIND IT!

The new FLASH-O-LENS offers foundry-men, machinists, and many others engaged in producing metal parts an efficient, economical means of examining the most minute defects during routine inspections.

FLASH-O-LENS consists of a portable 40x microscope combined with a perfect source of illumination in one convenient, compact unit . . . They are available in several models—powered by either standard flash light dry cells or by current from any AC or DC outlet—and with a selection of various combinations of lenses, all interchangeable in the one lens housing.

Send today for illustrated Catalog O describing the new FLASH-O-LENS

E. W. PIKE & COMPANY
Manufacturers of Illuminated Magnifiers
PIKE REG. U. S. PAT. OFF.
ELIZABETH 3, N. J.

Drum-Type Miller Has Multiple Cutter Mountings

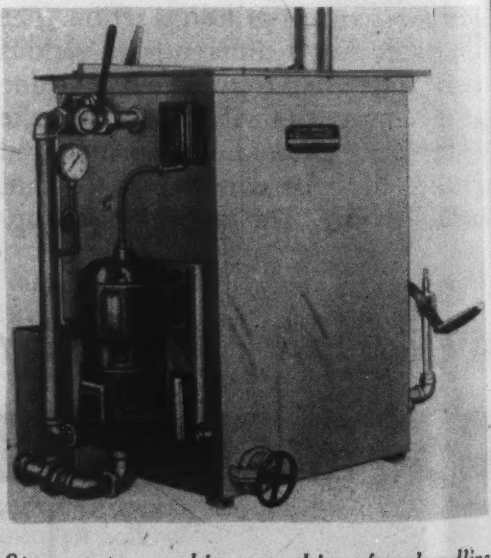
A drum-type milling machine permitting single or double milling of four pieces at once has been developed by the *Sommer & Adams Co.*, Cleveland 12, to speed production of studs, nuts, bolts, pins, strips, etc. Designated as No. 3 Craftsman, it can be used for straddle milling, slotting or facing of studs, nuts, bolts, pins and strips. It has multiple milling cutter mountings, automatic ejection of finished work, and easy access to cutters for adjustment or regrinding.

The drum rotating gearbox is mounted in the center of the frame and consists of a worm and a worm wheel driven by a hardened and ground worm and tractor bronze worm gear, with pick-off gears for changing the speed of the rotation of the drum.

The spindle drive V-belt pulley has a disc-type clutch for disengaging rotation of the cutter spindles and drum. The cutter spindle overhead arms are of the swing type to allow easy removal of the cutters.

Spray Type Washer Cleans Small Metal Parts

A new, spray type washing machine, for washing of parts on racks, has been announced by the ***Optimus Equipment** Co.*, 267 Church St., Matawan, N. J. This new machine can be placed directly on the floor; the top of the unit is at working height. Spray nozzles are adjustable and replaceable. The same machine can be used with submerged agitation to remove caked greases such as Tripoli Compound and abrasives.



Spray type washing machine for handling parts on racks.

This machine is designed to eliminate slow hand-cleaning of small metal parts. It can be used individually, or in series where the washing operation requires several steps, such as solvent wash, rinse, alkali wash, second rinse.

WHEN

- **YOUR BASIC HEAT TREATMENTS CALL FOR CHEAP LARGE-VOLUME ATMOSPHERE GENERATION**
- **YET . . . OCCASIONAL HIGH-CARBON WORK WOULD BE SENSITIVE TO CO_2 OR H_2O**
- **AND . . . SPECIAL CARBURIZING JOBS DEMAND ENRICHED ATMOSPHERES**

THEN

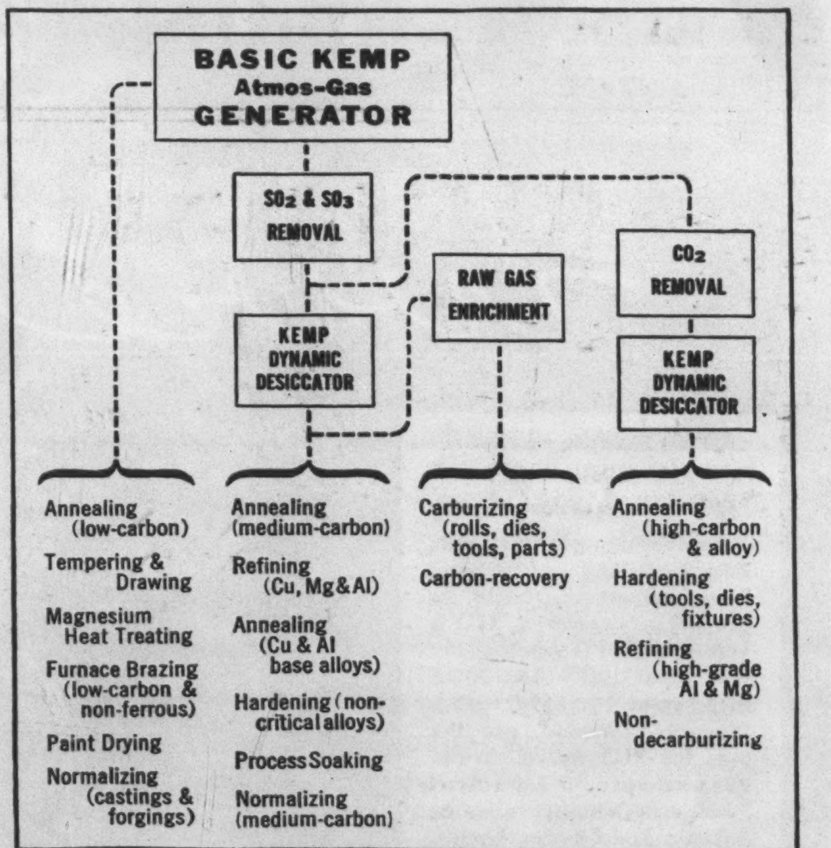
one central KEMP generator can serve all three needs

THAT'S because the basic KEMP atmosphere gas can now be modified for (1) complete desiccation, (2) complete CO_2 removal, (3) sulfur scrubbing, (4) odor removal, or (5) raw gas enrichment—any, or all, in any combination.

Thus, you can install one central atmosphere generator—fully automatic, of course—and tap off fractions of its output for special modifications to suit special needs.

The basic atmos-gas costs you only 8 to 20¢ per mcf (fuel, power, maintenance and depreciation)—the modifications, where you need them, a dime or so more.

The idea is new, but as sound as Gibraltar. Fill out the coupon for your copy of a complete 3-part technical report on the subject, just off the press.


BASIC KEMP Atmos-Gas GENERATOR
SO₂ & SO₃ REMOVAL
KEMP DYNAMIC DESICCATOR
RAW GAS ENRICHMENT
CO₂ REMOVAL
KEMP DYNAMIC DESICCATOR
Annealing (low-carbon)
Tempering & Drawing
Magnesium Heat Treating
Furnace Brazing (low-carbon & non-ferrous)
Paint Drying
Normalizing (castings & forgings)
Annealing (medium-carbon)
Refining (Cu, Mg & Al)
Annealing (Cu & Al base alloys)
Hardening (non-critical alloys)
Process Soaking
Normalizing (medium-carbon)
Carburizing (rolls, dies, tools, parts)
Carbon-recovery
Annealing (high-carbon & alloy)
Hardening (tools, dies, fixtures)
Refining (high-grade Al & Mg)
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KEMP *OF BALTIMORE*

PRECISION CARBURETION ✚ ADAPTED COMBUSTION FOR INDUSTRY'S HEAT USING PROCESSES
ATMOSPHERE GENERATION & ADSORPTIVE DRYER SYSTEMS FOR PROCESS CONTROL AND PROTECTION

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Send me without delay your complete 3-part report, "A Critical Survey of Controlled Atmospheres" ______ ☐

My processes are______

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POSITION______
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TO BANISH WATER BREAKS
BE SURE WITH **metso**

METSO
ACTIVE ALKALI
REG. U.S. PAT. OFF.

A "water break" on metal indicates tattletale grease. When you use Metso for cleaning metals, notice how the rinse water runs off completely *without* a break. Metso cleaning baths remove the dirt, grease and oil, producing a chemically clean surface which is then ready for plating or other finishing. Metso is adaptable to electrocleaning, spray-type or soaker-tank cleaning.

Write us for copies of Bulletins: "Metso 99 Sodium Sesquisilicate — Industrial Alkali & Detergent" and "Metso Granular Sodium Metasilicate — Its Properties & Uses."

Sodium Sesquisilicate U.S. Pat. 1948730, 2145749
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metso *Cleaners*

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Are you specifying JOHNSON XLO MUSIC WIRE?

The wire of a thousand uses.

Wherever high-grade, smooth, bright, polished surface wire, free from cracks, checks, or die marks is required, XLO is your answer. Gauges all the way from .003" (38,026 ft. to lb.) up to .200" (9 ft. to lb.). Diversified, indeed, are the uses for XLO MUSIC WIRE. For example: Mechanical Springs in endless varieties, Antenna Rods, Butter, Bisquit, Cake, Brick Cutters, Choke, Cookie Cutters, Control, Conveyor Belts, Dental Instruments, Fish Leaders, Flexible Shafts, Mandrels, Perforating Punches, Sewer Rods, Sizing Gauges, Ski Binders, Spark Gap Gauges, Tonsil Snares, Trolling Lines, Vibrating Screens, Wire Forms.

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JOHNSON STEEL & WIRE CO., INC.
WORCESTER 1, MASSACHUSETTS
NEW YORK AKRON DETROIT CHICAGO LOS ANGELES TORONTO

Filter System Removes Fine Particles from Coolants

To remove fine metallic particles in suspension in coolants used on machine tools, the *Inject-A-Flow Co.*, 67 N. Willow St., Montclair, N. J., have developed a self-contained filtering system. The system can be adapted to the requirements of any machine tool, including grinders.

It is claimed that the strainer medium can be made to exclude extremely fine particles without creating back pressure that would reduce the flow of coolant to the cutting tools. The system consists of a 7-gal. rectangular steel tank in which a strainer unit is mounted.

Lid of filter system opened to show relative position of strainer and pump units.

The pump unit is mounted on the lid of the tank, with the pump operating inside the strainer unit. The unit consists of a noncorrosive centrifugal pump connected to the motor through an extended shaft. Provision is made for recirculating coolant liquid.

Pneumatic Spin Riveter Has Interchangeable Heads

Schlack Manufacturing Co., 13255 Birwood Ave., Detroit 4, has announced an improved design of its pneumatic spin riveting machine. The riveter has four interchangeable heads—3/32 in., 5/32 in., 1/4 in., and 5/16 in. capacities, based on solid soft steel rivets.

The heads are screwed and doweled to the frame, are spring supported on a vertical column, and connected to a foot treadle for movement downward against spring to contact the work.

The machine operates at 75 to 80 psi., and the heads impart 4000 to 6000 short 1/4-in. maximum blows per min. to the rotating spindle and peening tool. The force and frequency of blows is controlled by adjusting an aircock on the valve.

(Continued on page 1584)

WHY FABRICATORS LIKE YOLOY - YOUNGSTOWN'S HIGH-TENSILE STEEL

Yoloy
is high in
impact strength

YOLOY has been specified for many tough jobs--such as the National Advisory Committee for Aeronautics wind tunnel at Cleveland, Ohio--because of its remarkable ability to resist shock, or impact at low temperatures.

In order to determine the impact value of Yoloy steels a "standard" notched bar is broken by a single blow on a pendulum type impact machine, at ordinary temperatures or at some specified temperature, and the energy required to break the bar is determined in foot pounds. The values obtained are comparative and provide useful information for the design engineer. Most steels increase their Tensile Strength and lose ductility as the temperature is lowered. Yoloy retains its resistance to impact to a greater degree than carbon steels at various temperatures.

Ability to resist shock at low temperatures is only one of several valuable characteristics of Yoloy steels--properties that are the outgrowth of 12 years' experience in satisfying the complex requirements of customers. If you need a steel that has high impact strength or extra tensile strength, one with unusual ability to resist corrosion and abrasion, one that is easy to form and easy to weld, specify Yoloy. Ask the District Sales Office that serves you for full details.

Sheets-Plates-Pipe and Tubular Products-Bars-Rods-Wire-Cold Drawn Carbon Steel Rounds-Tie Plates and Spikes-Conduit-Electrolytic Tin Plate-Coke Tin Plate.

QUALITY
TRADE MARK
YOUNGSTOWN
SERVICE

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GENERAL OFFICES - YOUNGSTOWN 1, OHIO
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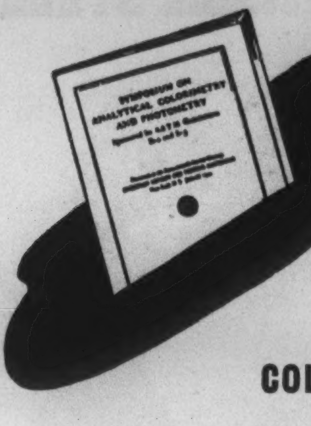
Manufacturers of
CARBON - ALLOY AND YOLOY STEELS



EVERY colorimetric determination reported in the 80-page booklet

SYMPOSIUM ON ANALYTICAL COLORIMETRY AND PHOTOMETRY

Sponsored by A.S.T.M. Committees E-2 and E-3

Presented at the Forty-seventh Annual Meeting, American Society for Testing Materials, New York, June 28, 1944

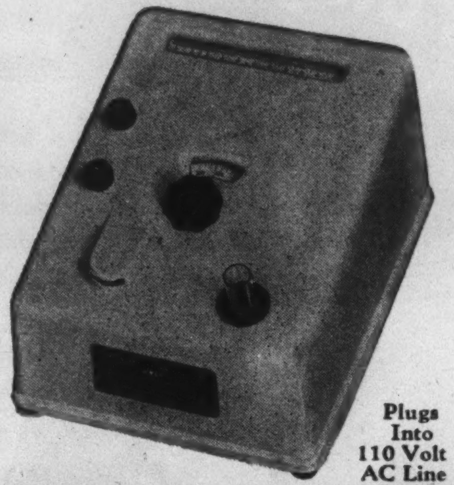
. . . . . may be done on the new simplified

COLEMAN **JUNIOR** SPECTROPHOTOMETER

See Page 726, "Spectrophotometers versus Filter Photometers." Copies of this comprehensive report are available for $1.00.

Coleman Spectrophotometers replace all filter photoelectric colorimeters as ANY band is available with the turn of ONE knob. The JUNIOR is a true Spectrophotometer so extra filters are not required . . . any wave band is available from 400 to 700 mm. at the turn of the selector knob. Accepts test tubes from 10 mm. to 1" diameter.

FREE—We will gladly send NEW water and steel analysis procedures by Dr. Max Herzog, Frisco Railway laboratory . . . and the Combined Method of Steel Analysis by W. H. Sobers of Chain Belt Co. Write Dept. MM-1246 for your copy.



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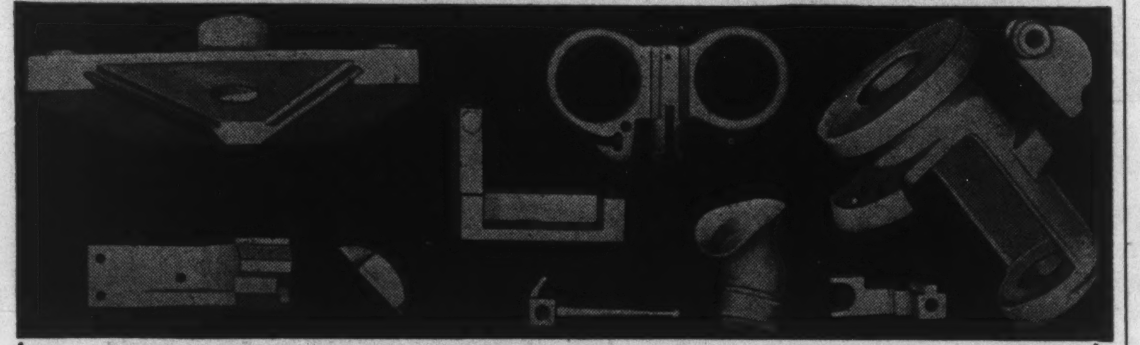


PRECISION INVESTMENT CASTING

Many small parts, covering a wide range of applications, are being produced in ferrous and non-ferrous metals by precision investment casting at substantial savings.

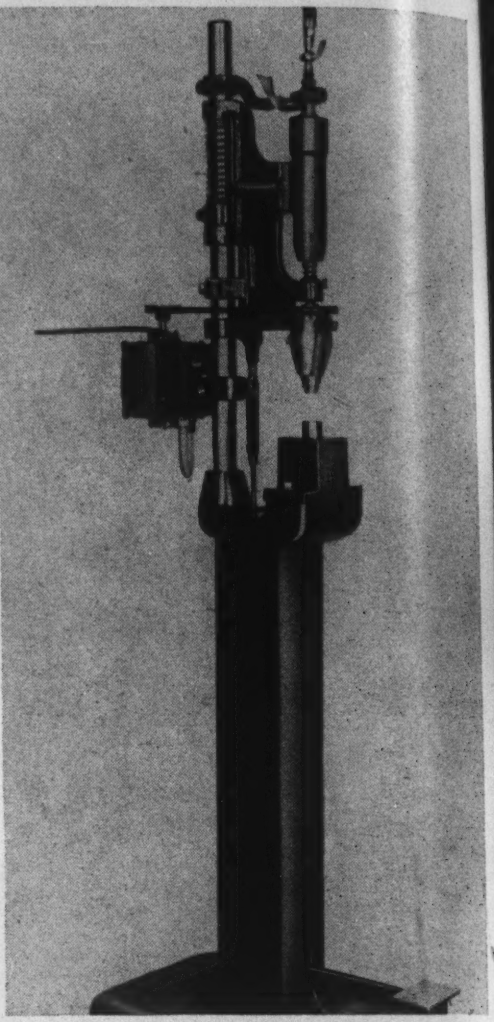
Production problems not easily met by conventional casting, forging or machining methods, may find a ready solution in this new, war developed method.

We can furnish, to established firms now engaged in precision casting, new equipment and a full line of operating supplies such as investments, pattern wax, flasks, tongs, fluxes, asbestos mittens, etc.

To manufacturers who wish to obtain specific pieces produced by precision casting methods we offer information regarding possible sources of supply. To those who wish to set up their own precision casting department, we supply detailed information regarding required equipment and operating supplies.

ALEXANDER SAUNDERS & CO.
Succ. to J. Goebel & Co.—Est. 1865
Precision Casting Equipment and Supplies
95 BEDFORD STREET NEW YORK CITY 14

Peening tools attached to the taper on the spindle will form round, oval and flat heads; peen shafts, pins and studs; flare tubing and brass connectors; furl shoulder bushings, bearing housings, and light tubes to sheet metal or plastics. It can be used to assemble metal as well as parts of wood fibre, porcelain and plastics.



The spin riveter has many uses including flaring tubing and connectors and furling operations.

Aluminum Alloys Finished to Resemble Brass and Chromium

The *Technical Processes Div., Colonial Alloys Co.,* Philadelphia 29, report a new finish for aluminum and its alloys that gives the treated surface an appearance closely resembling brass and chromium.

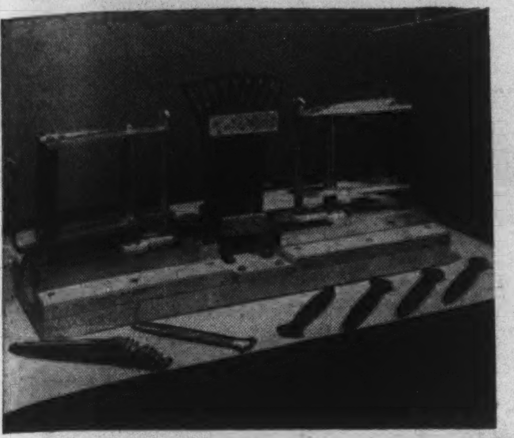
High reflective mirror effects can be obtained and after-lacquering is not necessary. The finished surfaces are said to have good corrosion resistance and abrasion resistance.

This finish is not a coating, but is part of the surface of the aluminum which has been electrochemically changed to produce the result.

The common aluminum alloys such as 2S, 3S, 52S, 53S, 56S, "Alclad" and "Pureclad" respond to this treatment. They should, however, be free of scratches, draw and roll marks, etc., or these will appear in the final finish. A pre-finish equivalent to a 200 mesh (or finer) treatment results in uniform reflective surfaces after treatment.

HIGH-FREQUENCY HEATING with LEPEL *Spark-Gap* CONVERTERS

No. 3



JOINING BRASS STAMPINGS 5 TIMES FASTER

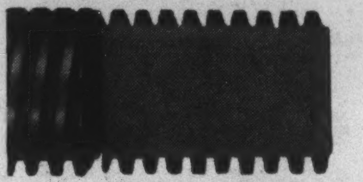
The two halves of handles for vanity mirrors were being joined by flame heating, using a silver alloy. The operation was becoming a bottle-neck — one *skilled operator* could complete less than 400 per day.

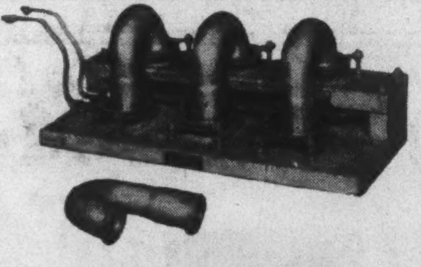
Lepel Laboratories developed this jig and heating coil for use with a spark-gap converter. Handles are now produced with less discoloration; joints are always uniform. Cleaning is appreciably reduced and rejects are eliminated. Cool, clean working conditions greatly improved the operation. Outstanding feature: with a single 15-kw Lepel unit and two jigs and coils, one *unskilled operator* produces 240 handles *per hour.*

4 HOURS GRINDING TIME SAVED BY INDUCTION-HARDENING LEAD SCREWS

Before induction hardening was tried, a large machine-tool manufacturer ground the threads of 1⅝-in. diameter lead screws from bars already hardened to 47-49 Rockwell C. This was necessary to avoid lead elongation in conventional heat treating. Grinding time was seven hours.

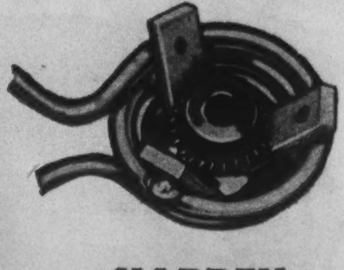
Now progressive induction heating, with Lepel equipment, is used to harden threads, only, as shown in etched cut-away. Service life is improved by the 55 to 60 Rockwell C hardness obtained on thread surfaces. Ductility is maintained at the thread roots. Threads are cut before hardening; average lead elongation of .0027 in. in a 42-in. screw is easily corrected by a quick finish grind. Machining time is now two to three hours.



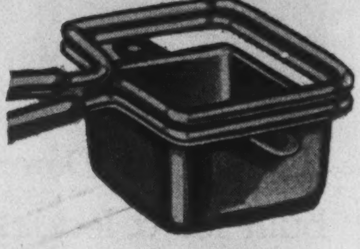


6 JOINTS SOLDERED EVERY 24 SECONDS

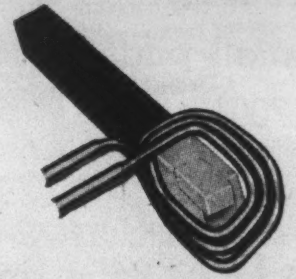
Soldering threaded connectors to brass elbows is an ideal job for a Lepel Induction Heating Unit. With a 15-kw unit, three complete elbows — six joints — can be soldered in 24 seconds. With two jigs and load coils, operation can be continuous, producing 450 elbows per hour. Discoloration is eliminated. High-frequency heating is not only faster and requires no skilled labor — it is cleaner, cooler, eliminates fire hazard and requires less space.



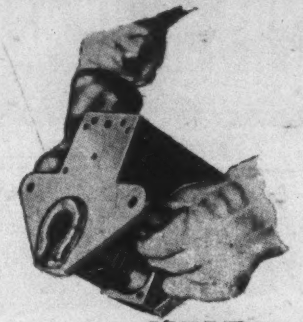
HARDEN



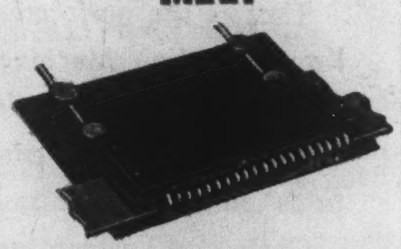
SOLDER



BRAZE



MELT



ANNEAL

STRESS RELIEVE

PREHEAT

NORMALIZE

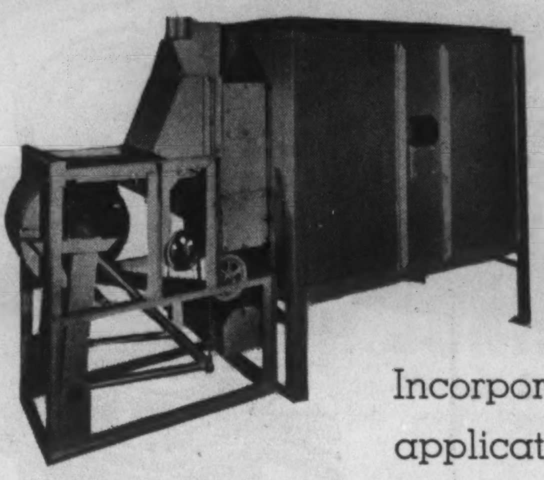
. . . ferrous and non-ferrous metals with the SAME Lepel unit

IF YOU HAVE A PROBLEM in joining, heat treating or melting of ferrous or non-ferrous metals, chances are that a Lepel High-Frequency Induction Heating Unit can help you to do a better, faster, more economical job. Lepel metallurgists and field engineers will be glad to make a thorough study of your specific problem, and help you put the right, compact, movable Lepel unit on the job. Call, or write, Lepel High Frequency Laboratories, Inc., 39 West 60th Street, New York 23, N. Y.

NOTE: Send for our 32-page catalog which gives a complete story on what high-frequency heating can do for you.

PIONEERS IN INDUCTION HEATING

Lepel
High Frequency
INDUCTION HEATING UNITS

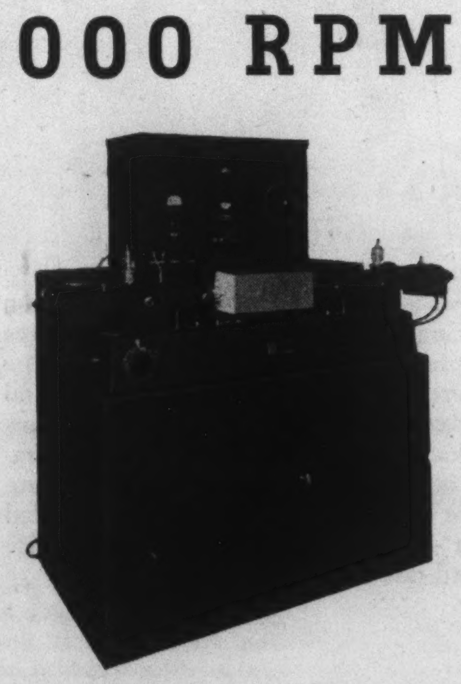


ANOTHER NEW
DEMPSEY FURNACE

Incorporating a radiant tube application to continuous production, this Dempsey furnace was designed and built for a leading belt maker to bright anneal both ferrous and nonferrous metal buckles and small parts under controlled atmospheres up to 1700°.

FURNACES: Oil-Gas-Electric-"TAILORED" by DEMPSEY
Meet every Heat Treating Need

DEMPSEY INDUSTRIAL FURNACE CORP.
Springfield 7, Mass.



1800°F—12000 RPM

That is the performance of this Krouse Testing Machine. Another Krouse machine leads in the field of fatigue testing. Outstanding features found in this unit:

Controlled Temperatures to ±2°.
Variable Speeds to 12000 rpm.
Accurate Stress Measurement.
Simple, Inexpensive Specimens.
Easy to Operate.

A complete rotating beam machine for elevated or normal temperatures. Corrosion adapters available. Write for Bulletin 46-F.

Additional elevated temperature machines manufactured by Krouse:
Plate Machine—062" to 3/8" plate—Bulletin 46-B.
Direct Stress Machine—5000 lb. and up—Bulletin 46-C.

LABORATORY SERVICE

KROUSE TESTING MACHINE COMPANY
573 E. Eleventh Ave. Columbus 3, Ohio

Drawing Press Features Single-Action Die Cushion Cylinder

A new 250-ton, double-action, drawing press, manufactured by the *Watson-Stillman Co.*, Roselle, N. J., features a single-action die cushion cylinder. The die ram is 11 in. in dia. and has a 14-in. stroke. When used as an ejector, it operates at 3.9 tons on 100 psi. pressure.

The press is self-contained, operating with a vane-type oil pump. The platen is 48 in. sq., the operating stroke is 36 in., and the machine operates at a pressure of 2000 psi. The machine has manual control and single-cycle automatic operation. Operating speeds are: advance, 600 in. per min.; pressing 82 in. per min.; return, 725 in. per min.

The same company also has a 150-ton heating press for plastic hot pressing and laminating. The machine has a stop valve which locks the pressure in and holds it for long periods. It also has a separate radial piston constant displacement pump with integral low-pressure gear pump that can be placed close to the press.

The press can be fitted with stand pipe and flexible hose connections for admitting steam and water for heating and cooling size 14 by 14 in. Operating pressure is the plates. The ram stroke is 16 in.; platen 2400 psi.

News of

Engineers — Companies — Societies

(Continued from page 1382)

and cover 19 acres. Unusually heavy steel will be needed for the superstructure, since the building will house 200-ton cranes.

Arthur D. Little, Inc., Cambridge, Mass., probably the oldest of existing consulting industrial research laboratories and the largest of those which are not endowed institutions, has celebrated its sixtieth anniversary. The laboratories were founded as Griffin & Little in downtown Boston in 1886. By now it has been extended to cover practically all fields of applied science. Dr. Arthur D. Little died in 1935.

Inland Steel Co. is purchasing a $13,250,000 surplus pig iron and coke making plant in East Chicago, having operated the plant for the government during the war.

Charles Engelhard, Inc., maker of industrial instruments, has moved to larger quarters at 900 Passaic Ave., East Newark, N. J.

Clarence Johnson, for 18 years research engineer at *Baily Meter Co.*, has left Cleveland for Beloit, Wis., where he has established himself as a research consultant on inventions and engineering developments. He holds many patents on mechanical,

ATMOSPHERE HARDENING

← Battery of 3 'Surface' Rotary Hearth Clean and Bright Hardening Furnaces . . . Radiant Tube Heated and utilizing an RX Gas Atmosphere.

Three 'Surface' RX Gas Generators supply the atmosphere to the furnaces below. ↓

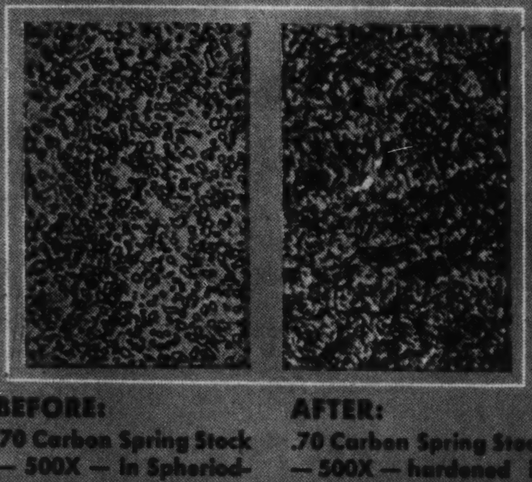
'SURFACE'
ACHIEVEMENTS
IN THE SCIENCE OF
GAS CHEMISTRY AND
HEAT TREATING

ATMOSPHERE HARDENING

with RX Gas retains a clean and bright heat-treated surface for metal pieces, in the finished form, thereby eliminating cleaning and extra machining operations otherwise required in the usual production procedure.

The development of equipment to accurately control the carbon balance between the metal being treated and an RX Gas Atmosphere is an important advancement in heat-treating practice. In this procedure no protective coating is needed to prevent carburization or decarburization of the steel surface. Extensive research in the Science of Gas Chemistry and Heat Treating, in which 'Surface' has pioneered, has made it possible to transfer these laboratory practices to actual shop production. Bulletins are available on the application of 'Surface' Prepared Gas Atmospheres to practically all heat-treating processes. Write, stating your particular interest.

BEFORE AND AFTER ATMOSPHERE HARDENING



BEFORE: .70 Carbon Spring Stock — 500X — in Spheriodized condition prior to hardening — 2% Nital etch.

AFTER: .70 Carbon Spring Stock — 500X — hardened in RX atmosphere at 1500° Fahr. oil quenched—2% Nital etch.

'Surface'

*** SPECIAL RADIANT-TUBE HEATED, ATMOSPHERE FURNACES FOR:** Gas Carburizing and Carbon Restoration (Skin Recovery), Clean and Bright Atmosphere Hardening, Bright Gas-Normalizing and Annealing, Dry (Gas) Cyaniding, Bright Super-Fast Gas Quenching, Atmosphere Malleableizing, Atmosphere Forging, and Specific Effects upon Metal Surfaces.

SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

HOW THE WROUGHT BRASS INDUSTRY CONSERVES METAL

No industry melting *commensurate tonnage of vital metal can quite match the brass mills for conservation and low melting losses. The savings of metal total millions of pounds; clearly the method they use is worth noting:**

Virtually all the brass mills in North America use the Ajax-Wyatt induction melting furnace, for it has the lowest metal losses in the field — less than 1% — with superior temperature control and unapproached economy of operation on high production schedules such as we have today.

The accepted melting tool in brass rolling mills throughout the world.

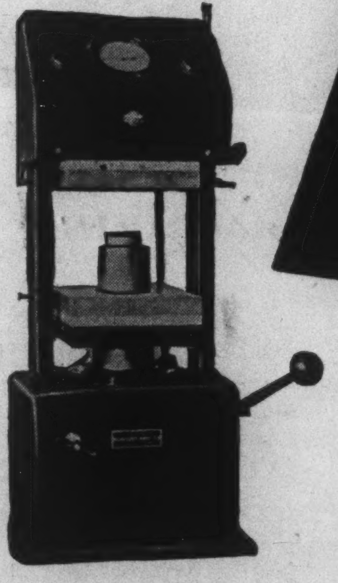
AJAX ELECTRIC FURNACE CORP.
1108 Frankford Avenue
PHILADELPHIA 25, PA.

*** UPWARDS OF 5 BILLION POUNDS ANNUALLY**

AEF CORP

THE AJAX WYATT INDUCTION MELTING FURNACE

ASSOCIATE COMPANIES:
AJAX METAL COMPANY, *Non-Ferrous Ingot Metals and Alloys for Foundry Use*
AJAX ELECTROTHERMIC CORPORATION, *Ajax-Northrup High Frequency Induction Furnaces*
AJAX ELECTRIC COMPANY, INC., *The Ajax-Hultgren Electric Salt Bath Furnace*
AJAX ENGINEERING CORPORATION, *Ajax-Tama-Wyatt Aluminum Melting Induction Furnaces*



It's a cinch!
WITH THE
PRECO
HYDRAULIC PRESS

The ideal press for fabrication of *both* rubber and metal molds. Metal mold frames up to 8" in diameter can be accommodated on the thermostatically controlled, electrically-heated, and water-cooled platens of this press.

The two stage hydraulic pump will exert pressures up to 40,000 pounds. In operation, the platens are brought together rapidly by the low stage of the pump, and when in contact with the work, the high-pressure stage automatically swings into operation, building up to 20 tons in sixteen strokes!

AVAILABLE IN EITHER A.C. OR D.C.

PRECO
Hydraulic Press

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EST. 1918
Precision Casting Sales and Engineering
64 W. 48th St. • New York 19
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Have you seen our new catalog? . . . **"PRECISION CASTING by the LOST WAX PROCESS"** . . . It's fast becoming the "bible" of the industry. Send for your **FREE** copy today.

chemical and automatic control inventions, and is author of technical articles on application of air and hydraulic controls to machine tools for automatically duplicating work pieces.

Installation of the first electronic frequency converting equipment in the United States for the production melting of alloy steels at the *Michiana Products Co.*, Michigan City, Ind. is announced by the *Allis-Chalmers Mfg. Co.* With it is being produced low carbon alloys, such as stainless steel.

A new firm has been organized, *Industrial Powders, Inc.*, 220 Essex St., Brooklyn, N. Y., equipped for production of electrolytic copper and copper oxide powders for all metallurgical uses and for the paint, electrical, plastics, chemical and automotive industries. G. B. Gusrae, formerly with Otis Elevator Co. and the U. S. Navy, is production engineer.

The Eagle-Picher Co., lead and zinc products, etc., has acquired the East Chicago plant of *International Smelting & Refining Co.*, subsidiary of *Anaconda Copper Mining Co.*

Foxboro Co., Ltd. is erecting a new plant in the Ville La Salle section of Montreal, which will consolidate machining, metal finishing and other basic operations, as well as assembly and calibration of instruments.

Edward S. Christiansen, president, *Bates Expanded Steel Corp.*, East Chicago, Ind., announces purchase of 16 acres at Torrance, Cal., on which will be constructed a new plant. Here it will make a patented line of structural building products and light metal products such as magnesium dockboards.

Skilsaw, Inc., Chicago maker of portable electric tools, has purchased the *Forss Pneumatic Tool Co.*, Aurora, Ill.

Eastern Engineering Co., New Haven, Conn., maker of midget pumps for industrial and laboratory use, has been consolidated with *Automatic Signal Corp.*, East Norwalk, Conn., maker of automatic traffic signals and relays, the new corporation being *Eastern Industries, Inc.*, New Haven 6, Conn.

The *Broden Construction Co.*, Cleveland, has changed its name to *Wean Equipment Corp.* to more readily identify its ownership and products, strip steel and wire mill equipment.

The *Cleveland Automatic Machine Co.* will merge with the *LeBlond Engineering Co.* under the name of *Cleveland Automatic Machine Co.*

The *Overly Mfg. Co.*, Greensburg, Pa., has bought *McAleenan Brothers Co.*, Pittsburgh, producer of boilers, tanks and other heavy plate products.

Societies

The *American Foundrymen's Assn.* will hold its 51st annual convention in Detroit, April 28-May 1, with the Book-Cadillac and Statler Hotels as joint headquarters. This is the sixth time the AFA has met at Detroit. A sand division has been formed by AFA, the seventh of its technical groups. . . . The first exposition to deal entirely with industry's materials handling problem will

TOUGHER THAN A SEVEN-DAY BEARD
...because it's Ethyl Cellulose

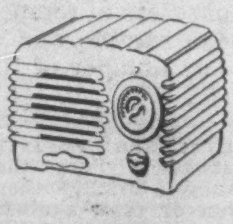
Handle molded by Mack Molding Company from Chemaco's Ethyl Cellulose

Schick's choice of ethyl cellulose for the handle of its famous Injector razor has resulted in many improvements for manufacturer and consumer.

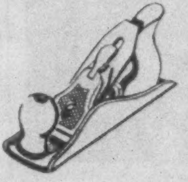
One outstanding property of ethyl cellulose is its resistance to cracking and chipping, even when dropped on hard surfaces. Another is its excellent dimensional stability, which assures a tight fit between plastic handle and metal through long periods of use, including cleaning in hot water. Pleasant to the touch, these new handles are made in dark blue, light blue, and brown mottle colors that retain their attractive appearance.

If your products have handles, or are frequently handled, it will pay you to know *more* about the serviceability and economy of ethyl cellulose molded parts.

Ethyl cellulose flashlight cases, proved best for Army use, now first civilian choice



Ethyl cellulose radio cabinets have high impact strength; excellent acoustical properties



Ethyl cellulose tool handles are tough, colorful, and pleasant to the touch

HERCULES

CELLULOSE ACETATE
CELLULOSE NITRATE
ETHYL CELLULOSE

For general-purpose production plastics

Hercules does not make plastics or molding powder, but supplies the high-quality cellulose derivatives from which they are made. For data, please write to
HERCULES POWDER COMPANY **INCORPORATED 907 Market Street, Wilmington 99, Delaware**

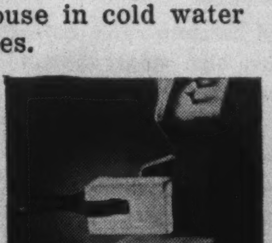
CP-73

SEND FOR this Brickseal coated BRICK

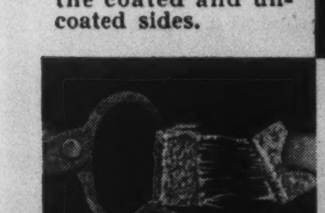
make this Test yourself

Brickseal penetrates the pores and joints of firebrick and forms a highly glazed ceramic coating many times harder than the brick.

Tough and semi-plastic under heat, it prevents cracking and spalling regardless of temperature change—heat the sample and douse in cold water any number of times.



Brickseal resists abrasion. Force the sample brick, either hot or cold, against an emery wheel and see the difference on the coated and uncoated sides.



Brickseal is a superior mortar for fire walls. Try to pull the sample bricks apart after they are heated to 2200°.

Write today for a free sample. No obligation, of course.

Brickseal
REFRACTORY COATING
5800 So. Hoover Street, Los Angeles, Calif.
1029 Clinton Street, Hoboken, New Jersey

be held at the Public Auditorium, Cleveland, Jan. 14-17, states Earl I. Burke, Republic Steel Co., chairman of the packaging and loading committee, *American Iron & Steel Institute.*

The *Steel Founder's Society of America,* Cleveland, has published a revised directory of steel founders in the U. S. and Canada. . . . The fifth *Western Metal Congress and Exposition* will be held in the San Francisco-Oakland Golden Gate area for six days, starting March 22, 1947. There will be technical papers of interest to the metals, aircraft, chemical, petroleum, mining and general manufacturing industries. . . . The *Optical Society of America* has presented the Adolph Lamb medal to Wayne G. Norton, Eastman Kodak Co., for research on fire-control instruments for shooting down enemy aircraft.

"For having rendered outstanding service to the industry which it represents and to the public" the *Magnesium Assn.* has received Honorable Mention from the *American Trade Assn. Executives.* The new president is R. D. Taylor, Federated Metals Div., American Smelting & Refining Co. . . . Two plastic societies, The *Society of the Plastics Industry, Inc.* and *Society of Plastics Engineers,* are taking steps to eliminate duplication of effort. . . . Headquarters of the *Felt Assn., Inc.,* have been moved to 74 Trinity Place, New York 6, with Herbert S. Blake, Jr., the new executive secretary.

The *Second National Plastics Exposition* will be held at the Coliseum, Chicago, May 6-10, a modification of previously announced dates of May 5-11. The sponsor is the *Society of the Plastics Industry.* . . . The *National Machine Tool Builders' Assn.* has elected as president Herbert H. Pease, president, New Britain-Gridley Div., New Britain Machine Co. . . . A. B. Campbell, formerly eastern representative, Hughes Brothers, has become executive secretary, *National Assn. of Corrosion Engineers.*

The *Engineering Foundation* has re-elected as chairman for the coming year Dr. A. B. Kinzel, vice president, Union Carbide & Carbon Research Laboratories, Inc. . . . The *American Society of Mechanical Engineers* has named several medal winners of 1946, the highest honor going to Morris Evans Leeds, chairman, Leeds & Northrop Co., for development of electrical and temperature measuring instruments. . . . The *American Institute of Mining & Metallurgical Engineers* has awarded the Lawrence Saunders Gold Medal for 1947 to LeRoy Salsich, president, Oliver Iron Mining Co.

Master Hands on Intricate Jobs use SHAWINIGAN CARBIDE

SHAWINIGAN CARBIDE
SHAWINIGAN

SHAWINIGAN PRODUCTS CORPORATION
EMPIRE STATE BUILDING,
NEW YORK 1, N.Y.

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MATERIALS & METHODS

Volume 24

July — December 1946, Inclusive

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Breaking Bottlenecks
in Heat Treating

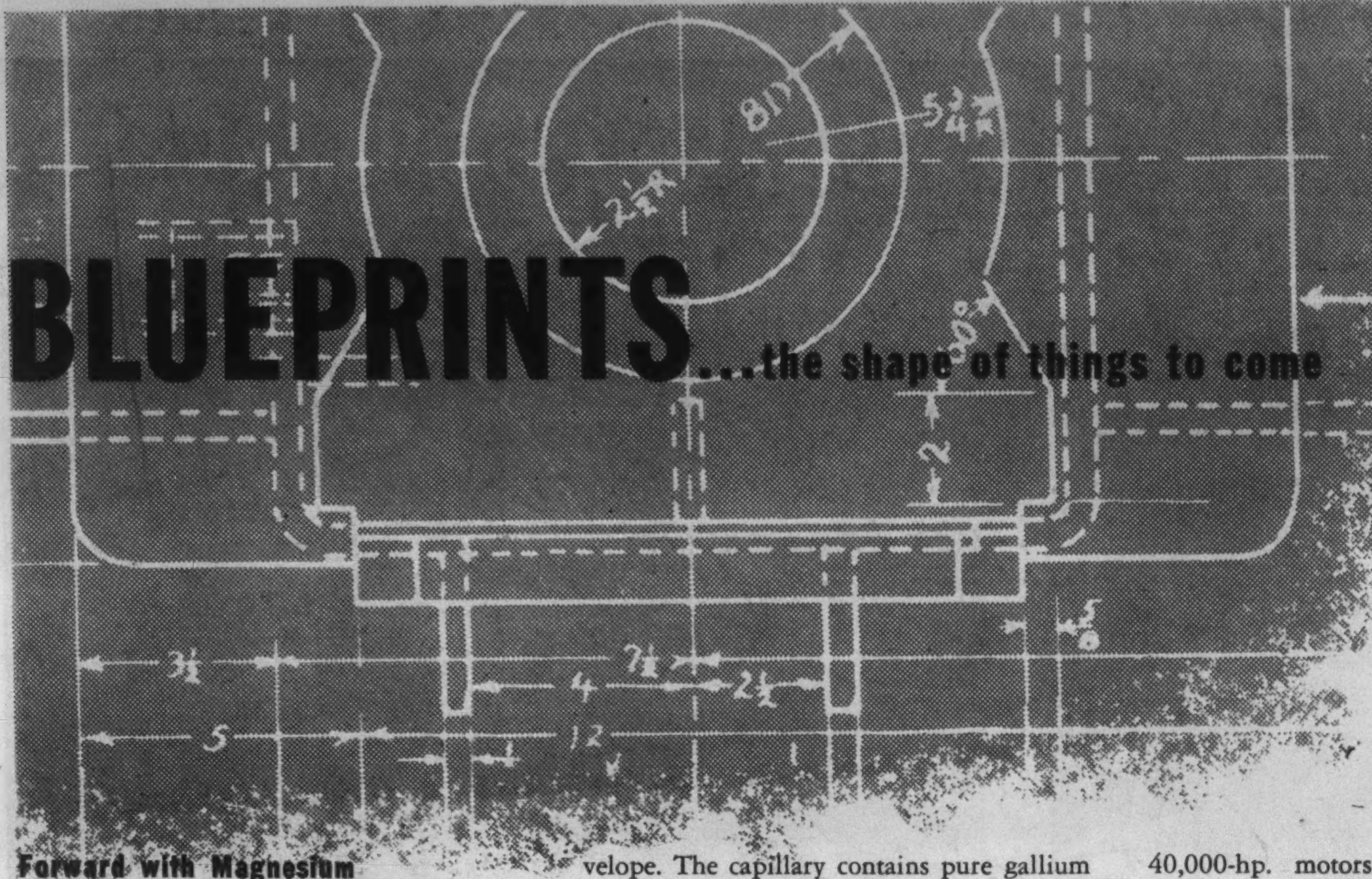
Breaking bottlenecks in heat treating is an everyday occurrence for Crystolon* hearth plates made by Norton Company. For a common bottleneck is the inability of less refractory plates to withstand the high temperatures and the severe wear and tear present in heat treating. The long efficient service of Crystolon hearth plates is due to these four important qualities: 1, High refractoriness to withstand both high heat and temperature changes. 2, Chemical stability to resist growth by oxidation. 3, Great strength to withstand any load. 4, Great hardness to resist abrasion.

NORTON COMPANY • Worcester 6, Massachusetts

**Crystolon is the registered trade-mark for Norton Company's silicon carbide.*

Norton Longer Lasting Refractories

BLUEPRINTS ... the shape of things to come



Forward with Magnesium

New electroplating of magnesium will provide an economical and decorative surface where exposure is mild. Cladding of sheet with a more anodic magnesium alloy will eliminate stress corrosion. Techniques for brazing magnesium parts will be worked out. Shot-blasting, used in Germany, will extend serviceability for magnesium parts that are highly stressed dynamically. Magnesium forgings will be cheaper than steel. "Mag" horseshoes for racers are now practical.

Hard-Facing Horseshoes

Speaking of horseshoes, your modern "Under the Spreading Chestnut Tree" artisan will not remove badly worn horseshoes but rather will build them up by welding on hard-facing material.

Extruding Wire?

Imaginative wire drawers are conscious of the present "horse and buggy" methods of producing wire. At present one draws a single strand of wire upon a bobbin or block—and calls that "production". Some inventor will devise an alloy equivalent to steel and extrude it through 100 orifices simultaneously. See how glass fibre and nylon are now extruded, for instance. Sooner or later we'll find a method of pushing wire through a die—not pulling it. Also, we may improve rolling technique and continuously reduce the wires by external pressure.

Aluminum Alloy Keys

Keys that no longer wear holes in the pocket seem slated to become the vogue. Made of aluminum alloys, they supplant the conventional nickel-plated brass jobs. They are 60% lighter and supposedly longer-wearing. Constant exposure to use improves their appearance. To be applied first to use in automobiles, they will eventually spread to more general use.

Gallium Thermometer

A new type of thermometer for use in metal producing and using plants consists of a quartz capillary inside a quartz envelope. The capillary contains pure gallium with a slight trace of iron. It can be used for direct temperature readings up to 1200 C, and can be used for measuring temperatures which could otherwise be measured only by thermocouples, disappearing filament pyrometers, or other indirect means. It is intended chiefly for 950 to 1000 C temperature. It has already been used outside the United States.

Refining Aluminum Scrap

We may adopt from the Germans a method of refining aluminum airplane scrap so that it may be reused in all but most critical aircraft parts. An excess of molten magnesium is added to crudely refined melted scrap aluminum alloy. This results in formation of insoluble intermetallic compounds of aluminum and magnesium with iron, manganese, silicon, chromium, vanadium, molybdenum, titanium, zirconium and cerium, compounds which can be filtered out as crystals when cooled near the point of solidification.

Cheaper Electrical Contact Alloys

Iridium platinum for durable electrical contacts for communications and automotive equipment are expensive and Americans may some day be using alloys of gold and zirconium, beryllium and platinum, and tungsten and platinum as overlays or inlays to base metals. At least the Germans used these substitutes successfully. They used 95% platinum and 5% tungsten for ignition and magneto contacts. An alloy of gold and 3% zirconium had a hardness of over 300 Brinell.

Radical New Combustion Motor

A Finnish inventor offers a new type internal combustion motor for development in the United States. It has a turbine-like movement, non-jolting. The cylinders are homocentrically located around the driving shaft and parallel with it. It is only one-quarter the size of the present motor of same capacity; no crankshaft is needed; only roller bearings are used, and sparsely; there are no bulk movements, back and forth; the motor operates identically in opposite directions; only two blast pipes are used. Over 40,000-hp. motors can be built. It is adapted to ship propulsion.

Energy Storing Bicycles

Why not store up the energy generated when coasting down hill for helping on the climb of the next hill? Experimenters are using a dynamo or motor — say a hub dynamo for bicycles. The British are making strides with this. Apparently automobile-scarce Europe is a more fertile field than the U.S.A. In an experimental British model, the conventional tubular construction is conspicuous by its absence.

Cart-Before-the-Horse Casting

We may adopt from the Soviets a new method of casting metal by "frosting" or crystallization. The inside walls of the mold are cooled by circulating water, the mold being immersed into molten metal and left until the outside walls are covered or frosted with an even layer of the desired thickness. It has been carried out successfully with bronze bushings, and is being experimented with as to other alloys and metals. The castings are reputed of high quality and smooth surface. To say the least, it is a hind-side-to way of casting!

Cold Extrusion of Steel Shapes

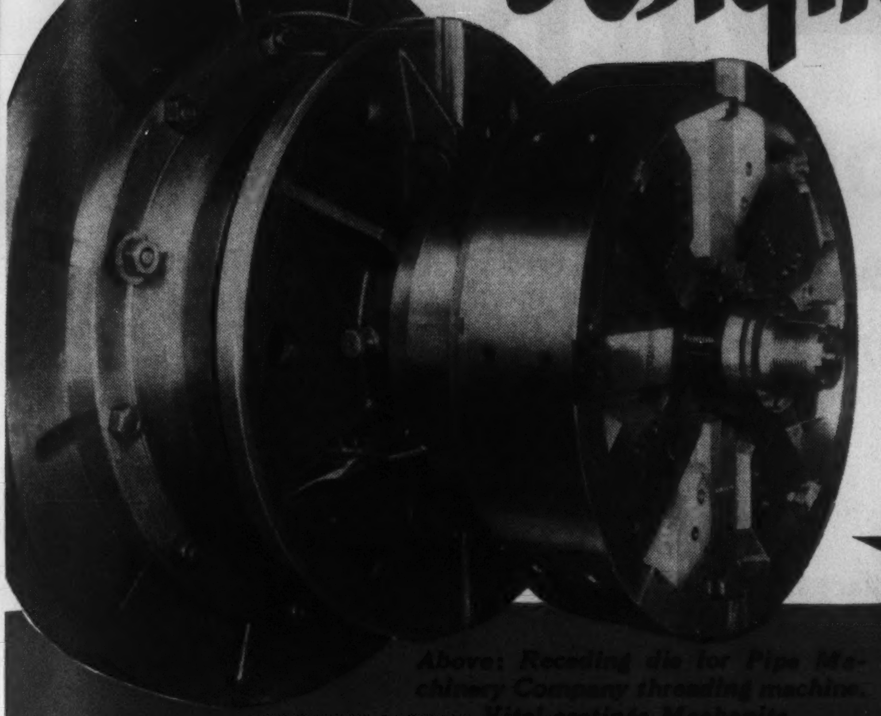
Cold extrusion of steel shapes is possible, it is learned from the Germans. They extruded cartridge cases, airplane landing gear cylinders and fuse bases. Several annealing, pickling and machining operations are eliminated. A bonderizing treatment is administered before the extruding, serving both as a lubricant and a lubricant carrier. U. S. Army Ordnance will import these machines.

Permanently Tuned Pianos

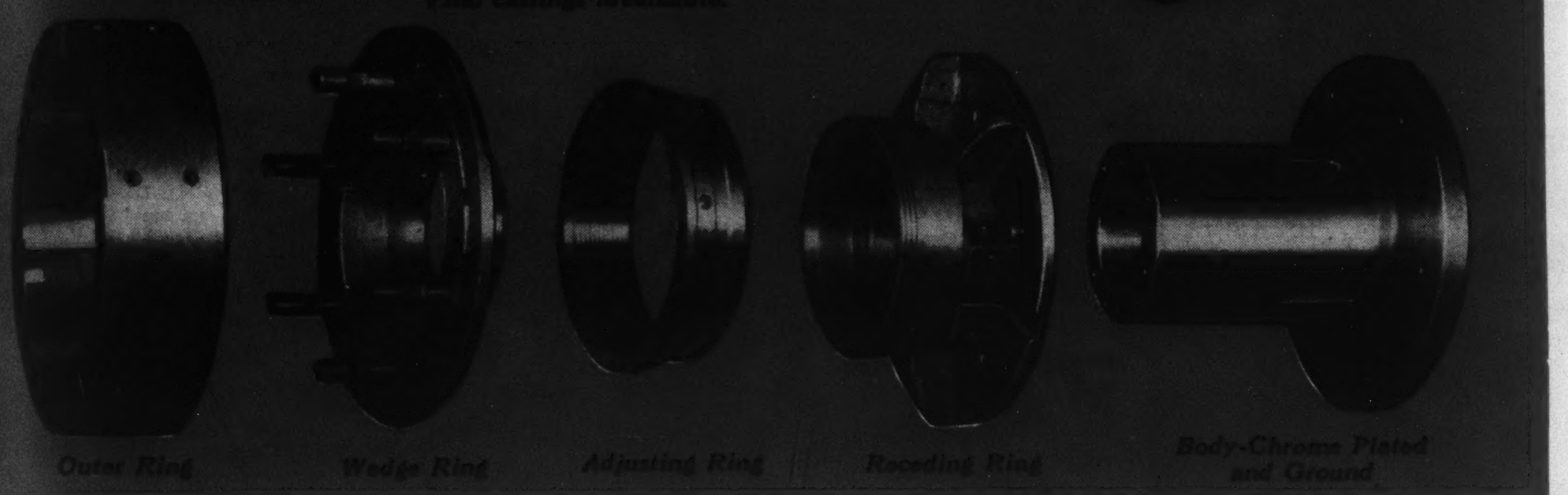
You who have pianos in summer cottages near the water or other humid places, listen to the story of Irving Berlin. He has a specially made piano at his Bermuda home where action parts are made of molded and extruded plastic components, remaining stable under difficult climatic conditions. The action remains in accurate adjustment and does not need re-tuning. The maker claims: "95% permanent regulation".

Designed to be better with

MEEHANITE CASTINGS



Above: Receding die for Pipe Machinery Company threading machine. Vital castings Meehanite.



Outer Ring

Wedge Ring

Adjusting Ring

Receding Ring

Body-Chrome Plated and Ground

STORIES OF
MEEHANITE
IN INDUSTRY

Write for our Bulletin
No. 22 "Stories of
Meehanite in Industry."

Only quality, high precision machinery is produced by The Pipe Machinery Company, Cleveland, Ohio. Outstanding in their line is pipe threading equipment producing API quality threads.

Illustrated is a receding chaser die for pipe threading and the five *important* Meehanite Castings embodied in its construction.

Note that the body casting is chrome-plated and ground, to extremely close tolerances. All these Meehanite Castings are produced in Type GA Meehanite providing a minimum tensile strength of 50,000 psi (1.2" diameter test bar), uniformly solid, dense and machinable castings, which maintain their original accuracy permanently.

When analyzing the component parts of your equipment be sure you are acquainted with the superior properties and high quality which can be built into it with Meehanite Castings.

"Meehanite *Means* Better Castings"

MEEHANITE

Pershing Square Building
New Rochelle, N. Y.

ELECTRIC BRAZING FURNACES PROVED BY 40 YEARS

Every G-E Furnace Brings You These "Plus-dividends" of Leadership—

★**Performance-proved Construction**

★**Technical Assistance**

★**Nationwide Field Service**

Pioneer and leader in electric furnace brazing since 1906, General Electric is well prepared to fulfill your furnace needs with performance-proved equipments—with designs steadily improved by forty years of experience, research, and development. G-E "know-how" is available to assist in product and process improvements by suggesting proper techniques, both before and after you buy your brazing furnace. And an expert field engineering organization is maintained in major cities throughout the country to speed installations, help solve operating problems, and to be readily available for servicing of equipment.

Better Products by Brazing—Electric furnace brazing merits consideration as both a cost reducer and as a likely means of *improving your product*. Here are some of the reasons:

1. Manufacturing costs may be substantially reduced by substituting the fabrication of inexpensive subassemblies (stampings, screw-machine parts, tubing) for forgings, machining, and castings.
2. The great strength of furnace-brazed joints often means increased life of subassemblies and therefore reduced service costs.
3. Gas tight joints are made possible to an unusually high degree.
4. Bright surfaces and smooth fillets (without subsequent cleaning operations) mean excellent appearance.

Furthermore, furnace brazing permits savings in time, material, weight, and space. It is adaptable to both high and low production rates, and its flexibility permits a variety of assemblies to be handled with a single equipment.

Roller-hearth furnaces, for high-quantity production, operate continuously months on end at 2050 F without shutdowns for repairs—thanks to well-supported, heavy ribbon-type heating units; large-diameter, low-stressed alloy rolls; and other conservatively designed features. Here, steel-fin refrigerator condensers, each with brazing metal (copper) preplaced at 800 joints, are brazed in a single trip through the controlled-atmosphere heating and cooling chambers of these furnaces.

General Electric Company
Apparatus Department, Sect. 675-128
Schenectady 5, N. Y.

Please send me bulletin GEA-3193B, "How and Where to Use Electric Furnace Brazing," and also the following (please check): ☐GEA-4066, Box Furnaces; ☐GEA-4071, Mesh-belt Conveyor Furnaces; ☐GEA-4072, Roller-hearth Furnaces.

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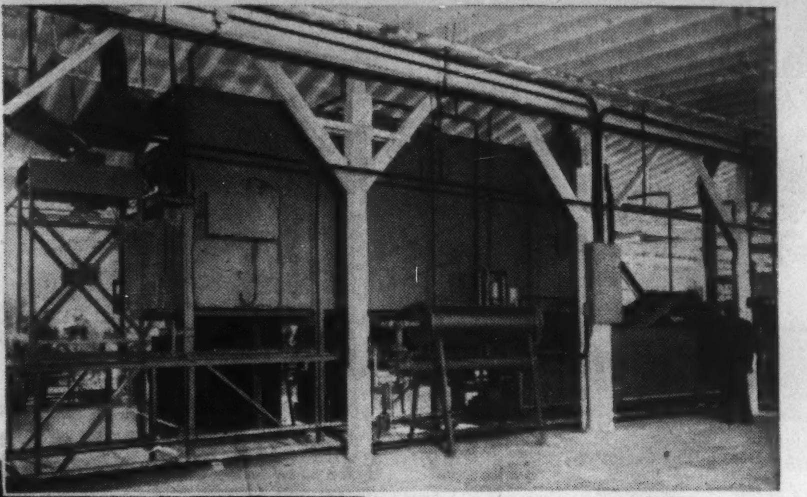
FOR PRECISION HEAT-TREATING AT

...AND IMPROVED

FURNACE BRAZING EXPERIENCE

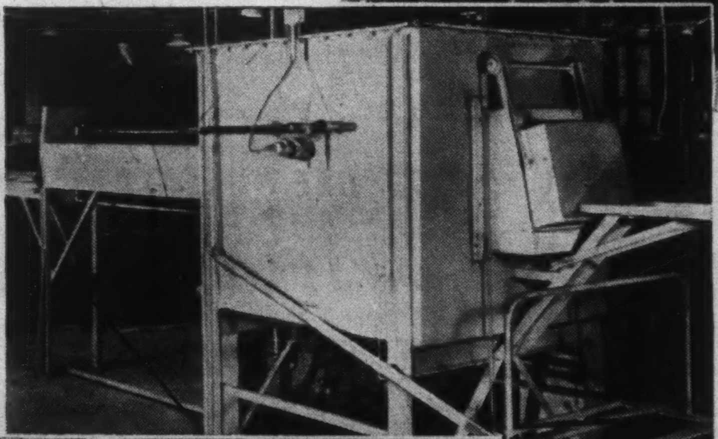
You reap the benefits of G-E "know-how" on these heating equipments, too . . .

In addition to brazing furnaces, G.E. builds electric furnaces for virtually every type of heat-treating process. Here are just a few:

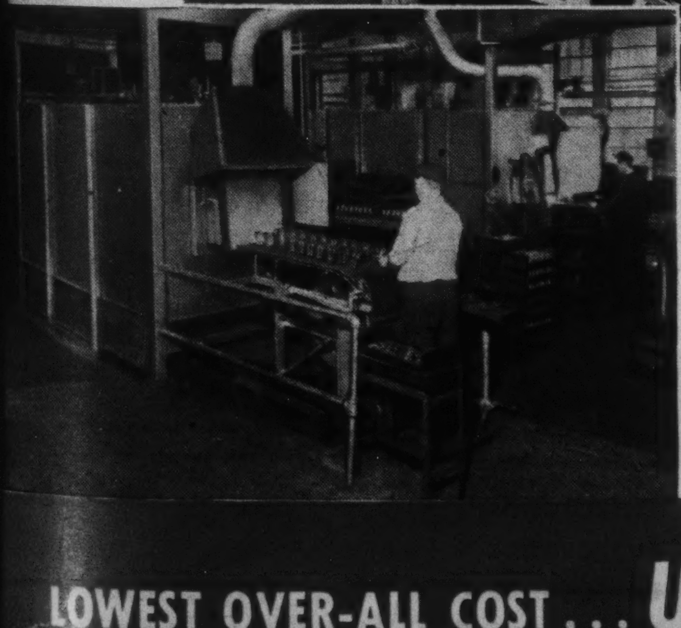


▲ **Belt-conveyor hardening furnace**—for uniform, automatic, *clean* hardening, without decarburization, of bolts, bearing races, business machine parts, and many similar products.

Porcelain-enameling furnace—This continuous-type conveyor furnace produces a durable, high-lustre finish in porcelain enameling of cast-iron and sheet-steel stove and range parts, kitchenware, signs, table tops, refrigerator liners and cabinets. ▶



◀ **Box furnace**—ideal for jobbing shop or small-scale production for furnace-brazing, bright annealing, bright normalizing, scale-free hardening, and sintering powdered-metal compacts. The well-supported heating units may be nickel-chromium ribbon (2100 F max. operating temperature), silicon carbide (2500 F max.), or moly rod (2750 F max.).



Mesh-belt conveyor furnace—A flexible, continuous-type equipment for high-quality brazing, bright-annealing, bright normalizing, and sintering. Heating *and cooling* take place within the protective atmosphere to assure clean, bright work.

General Electric has also had wide experience in the development and construction of electronic induction and dielectric heaters for a variety of applications, in addition to furnaces and small heating devices. Our heating specialists and application engineers are prepared to recommend the electric heating equipment most suitable for your process.

GENERAL ELECTRIC

LOWEST OVER-ALL COST... USE ELECTRIC FURNACES

EUTECTIC ADAPTS ITS WELL KNOW
TO ARC WELDING!

A NEW LINE OF SPECIAL "LowTemp" EUTECTRODES TO LICK ALL "HARD-TO-ARC WELD" PROBLEMS IN CAST IRON, STAINLESS STEEL, COPPER, AND ALUMINUM ALLOYS

EUTECTIC'S OUT FRONT WITH THIS STAR HEADLINER!

—first in a line of revolutionary electrodes

A NEW DEVELOPMENT FROM THE EUTECTIC RESEARCH LABORATORIES

—that's a step ahead in arc welding!

FROM the research laboratories of the originators of the revolutionary "*Low Temperature*" WELDING RODS* comes another remarkable achievement — "*LowTemp*" EUTECTRODES — a complete line of flux-coated electrodes for metal arc welding at *lower base metal temperatures*.

"*LowTemp*" EUTECTRODES have been developed to solve difficult welding problems on practically every type of metal. No longer is it necessary to use hot, digging-in method — thus the ill-effects of high heat have been greatly reduced. A special "*LowTemp*" flux coating insures immediate bonding of the weld deposit to the base metal. You'll get strong, smooth welds faster, better, more economically.

For ease of identification, the type of rod and its use is clearly stamped on each EUTECTRODE—another unique EUTECTIC feature! Solve your hard-to-lick arc welding problems with one of the appropriate "*LowTemp*" EUTECTRODES. MAIL COUPON ON OPPOSITE PAGE FOR FULL DETAILS.

USE THESE AMAZING "LowTemp" EUTECTRODES TO SOLVE YOUR PROBLEMS

EUTECTRODE 24 (AC-DC) for CAST IRON, "Cold", no preheating, machinable.

EUTECTRODE 24B (AC-DC) for CAST IRON, corrosion-heat resistant, machinable.

EUTECTRODES 28 (AC) and **280** (DC) for BRONZES, BRASSES, fabrication, repair, amazingly dense.

EUTECTRODES 30 (AC) and **300** (DC) for COPPER, smooth, dense welds.

EUTECTRODES 29 (AC) and **290** (DC) for REDDISH and SILICON BRONZES, smoothest welds.

EUTECTRODE 2100 (DC and Gas) for ALUMINUM, ideal for sheets, castings.

EUTECHROM group for maximum hardness to protect easily worn surfaces (ferrous only)

EUTECTRODE 2 for GENERAL USE.

EUTECTRODE 4 for MANGANESE STEEL, impact.

EUTECTRODE 6 for TOOLS, KNIVES, DIES.

EUTECTRODE 8 for CORROSION and HARDNESS.

EUTECTRODE 12 for DRILLING, EARTH MOVING PARTS.

EUTECTRODE 130 for CAST IRON.

Low Temperature WELDING RODS*

STAINLESS "*LowTemp*" EUTECTRODES for stainless steels

These amazing Stainless "*LowTemp*" EUTECTRODES oated with a specially developed flux, magically surface lloy the molten drops of weld metal to the base metal — t *lower base metal temperatures!*

This remarkable development avoids deep penetration nto the base metal, and the ill-effects that result from rge over-heated areas — which are characteristic of rdinary, high heat welding methods.

EUTECTIC Stainless "*LowTemp*" EUTECTRODES possess ll the beneficial qualities of stainless steel, including exeptional resistance to corrosion and oxidation. Smooth, eat deposits are easily obtained at exceptionally high peed, with no spattering, undercutting or overlapping.

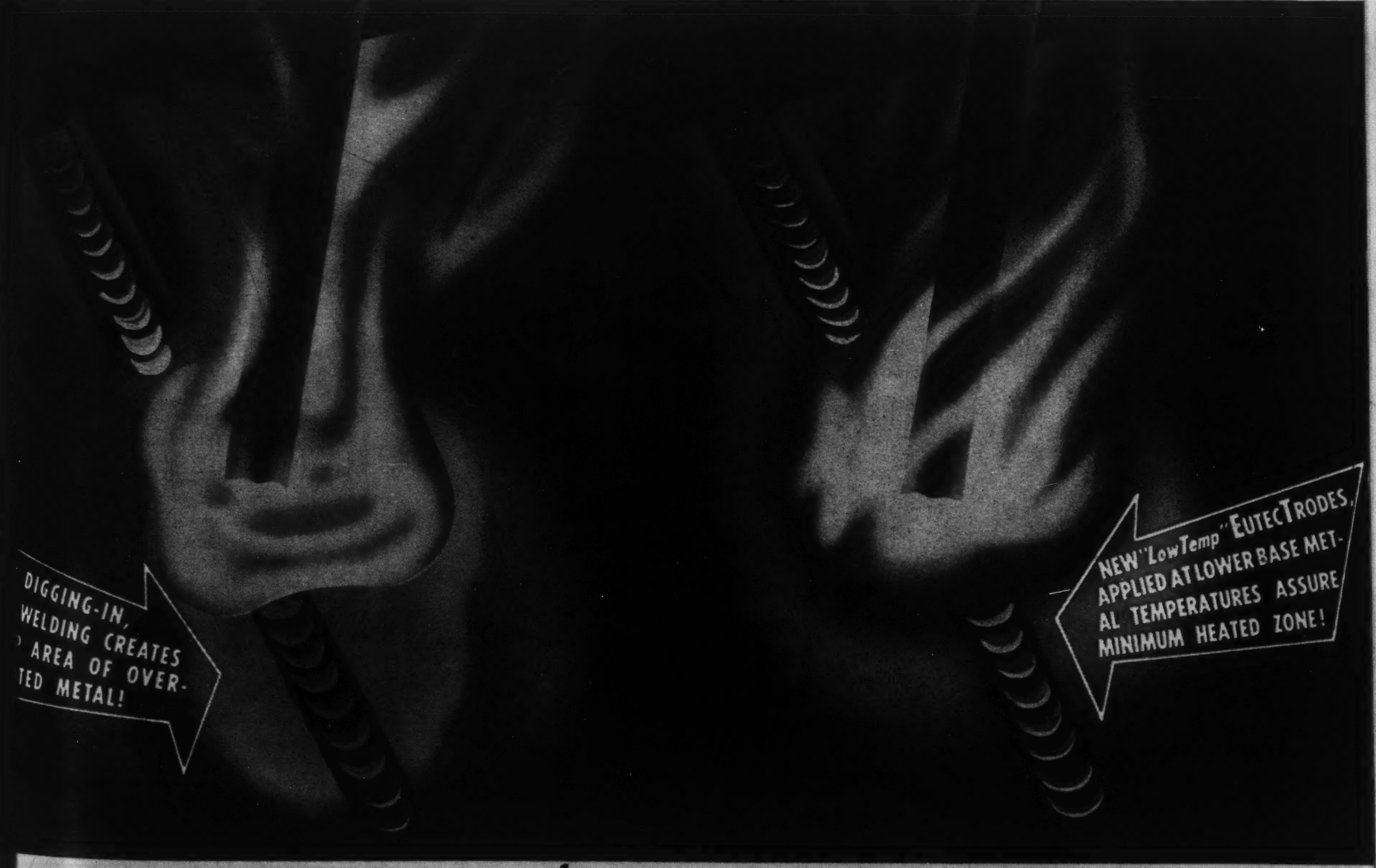
Stainless "*LowTemp*" EUTECTRODE 18/8 for stainless steel, types 301, 302, 303, 304, 308, 321, 347. Contains columbium. For DC use. AC rods upon request.

Stainless "*LowTemp*" EUTECTRODE 25/12 for stainless steel type 309, and stainless clad steel. For DC use. AC rod upon request.

Stainless "*LowTemp*" EUTECTRODE 25/20 for stainless steel type 310. For AC-DC use.

EUTECTIC "*LowTemp*" EUTECTRODES

are new types of metal arc welding electrodes which— *1. Weld at lower base metal temperatures. 2. Deposit welds at exceptionally high rates of speed. 3. Form welds equal to or better than base metal.*



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QUALITY WITH
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Originators of *Low Temperature* WELDING ALLOYS*

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☐ CAST IRON ☐ STAINLESS STEEL ☐ COPPER

☐ ALUMINUM ☐ BRASSES, BRONZES ☐ EXTRA-HARD OVERLAYS

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Address........................

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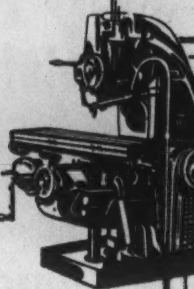
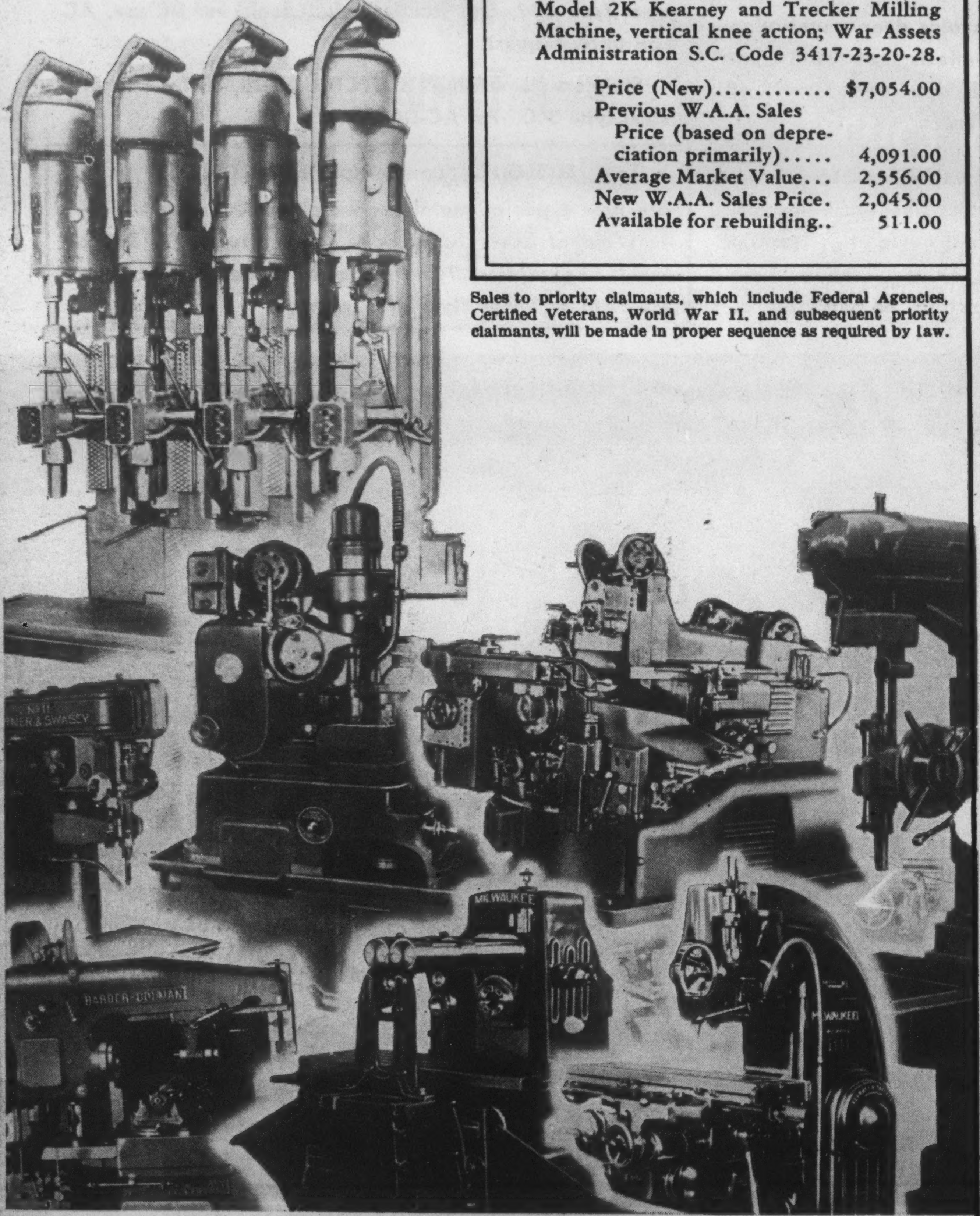


TYPICAL CASE—
MILLING MACHINE

Here is how War Assets Administration's new price has been set for a typical machine; Model 2K Kearney and Trecker Milling Machine, vertical knee action; War Assets Administration S.C. Code 3417-23-20-28.

Price (New)............	$7,054.00
Previous W.A.A. Sales Price (based on depreciation primarily).....	4,091.00
Average Market Value...	2,556.00
New W.A.A. Sales Price.	2,045.00
Available for rebuilding..	511.00

Sales to priority claimants, which include Federal Agencies, Certified Veterans, World War II. and subsequent priority claimants, will be made in proper sequence as required by law.



31 TYPES OF GENERAL PRODUCTION TOOLS REPRICED

- Boring Machine—Horizontal, Precision, Bridge Type, Single and Double End
- Chucking Machine—Automatic, Vertical, Multiple Spindle Type
- Chucking Machine—Single Spindle Automatic, Horizontal Turret Type Machine
- Chucking Machine—Six Spindle Automatic, Horizontal
- Drilling Machine or Drill Press—Bench or Floor, Single or Multiple Spindle
- Gear Cutting Machine for Straigh Bevel Gears, (Not Planer Type)
- Gear Hobber—Horizontal
- Gear Hobber—Vertical, Universal
- Gear Shaper—For External Spur Gears Only
- Gear Shaper—For Spur Gears, External or Internal
- Gear Shaper—For Spur and Helical Gears, External and Internal
- Gear Tooth Shaver—For External and Internal Gears (Rotary Type Machine)
- Gear Tooth Grinder—Generating Type, for Spur and Helical Gears
- Gear Tooth Grinder—For Spur Gears, External and Internal (Formed Wheel Type Machine)
- Grinders—Centerless
- Grinder—Crank Pin Grinders
- Grinders—Plain External Cylindrical Grinder
- Grinder—Internal, Cylindrical, Automatic Sizing
- Grinder—Internal Cylindrical (Hydraulic Feed Machine)
- Grinder—Internal Cylindrical, Hydraulic Feed, for Hole and Face Grinding
- Grinder—Surface, Rotary Table Type
- Lathe—Multiple Tool, Not Automatic, Manufacturing Type Production Lathe
- Milling Machine—Automatic and Manufacturing Knee Type
- Milling Machine—Plain Bed Type, Horizontal Spindle Machines
- Milling Machine—Vertical, Knee Type (Not Including Bench Type)
- Polishing and Buffing Machine—Bench and Floor
- Profiling Machine—Vertical, Fixed Bed Type, Single and Multiple Spindle
- Tapping Machine—Vertical, Single or Multiple Spindle
- Thread Grinding Machines
- Thread Milling Machine
- Turret Lathe—Ram Type, Plain and Universal

MACHINE TOOL
SALES DIVISION

BELOW MARKET

NEW "FIXED PRICE" POLICY ESTABLISHED ON 31 TYPES OF SURPLUS MACHINE TOOLS

Here is good news indeed for the man who is trying to purchase general purpose production tools for replacement, reconversion or new enterprises. Now you can go into any of War Assets 33 Regional Offices, any machine tool site sale in the United States, or any approved War Assets Administration dealer and buy at the same fixed price, everywhere, the tools in these 31 groups listed at the left. No waiting for complicated figuring of prices, checks against priorities or other delaying factors. The tools are available in such quantity that your purchase can be cleared on the spot, and immediate delivery arranged.

But even more important is the principle under which the new low prices have been set. As the scale at the right indicates each price takes into consideration your costs of rebuilding the tool to new condition, engineering, service, etc. It is set well below the current market price for similar equipment sold on a full service basis. The differential is approximately 25% below market—enough for men with tooling "know-how" to realize a neat "extra" profit and at the same time acquire modern machine tools.

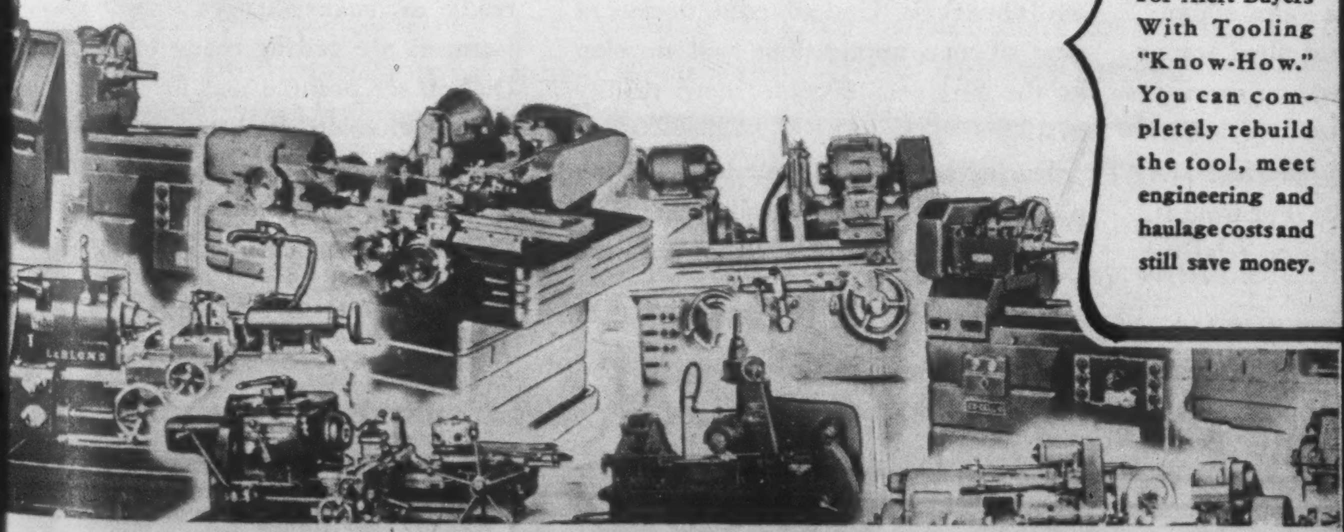
Plan now to check at once the detailed price and specifications list—now available in every War Assets Administration office (machine tool sales division) and the offices of your approved W.A.A. machine tool dealers.

FOR DETAILED PRICE CATALOG—
WRITE, WIRE OR PHONE:

1. *Your Regular Machine Tool Dealer*
War Assets Administration has appointed more than 3,000 "approved" dealers throughout the U. S.
2. *W.A.A. Machine Tool Sales Division*
In any of the 33 War Assets Administration Regional Offices listed below.

EXTRA PROFIT AREA

For Alert Buyers With Tooling "Know-How." You can completely rebuild the tool, meet engineering and haulage costs and still save money.



686-1

W. A. A.'s NEW PRICING PRINCIPLE

ORIGINAL COST

↕

DEPRECIATION BASED PRIMARILY ON TIME

↕

PREVIOUS W.A.A. PRICE

↕

OBSOLESCENCE FACTORS

↕

FULL SERVICE MARKET VALUE

↕

ALLOWANCE FOR COMPLETE REBUILDING AND ENGINEERING SERVICE

↕

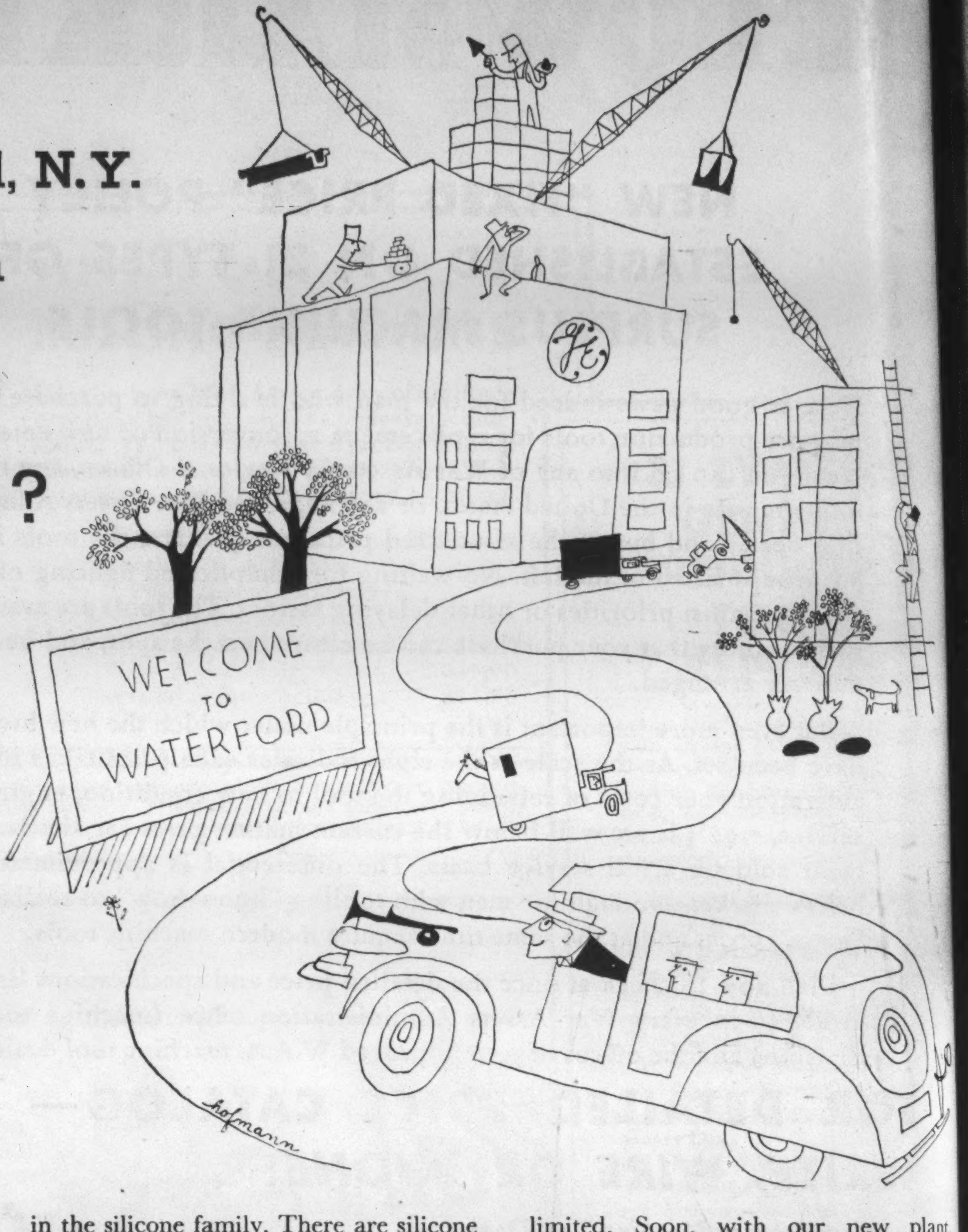
NEW PRICE LEVEL

WAR ASSETS ADMINISTRATION

GOVERNMENT
OWNED
SURPLUS

Offices located at: Atlanta • Birmingham Boston • Charlotte • Chicago • Cincinnati Cleveland • Dallas • Denver • Detroit • Fort Worth • Helena • Houston • Jacksonville Kansas City, Mo. • Little Rock • Los Angeles Louisville • Minneapolis • Nashville • New Orleans • New York • Omaha Philadelphia • Portland, Ore. • Richmond St. Louis • Salt Lake City • San Antonio San Francisco • Seattle • Spokane • Tulsa

What has Waterford, N.Y. got to do with BETTER HEARING?



WELL, Waterford, N. Y., is where we're going to do something new about an old hearing aid problem—moisture. On damp, humid days, hearing aids need protection from moisture. For moisture, condensing around the sensitive electron tubes, causes noisy static. At Waterford, where we're building our plant to produce silicone products, we will be able to supply that protection with DRI-FILM, G.E.'s remarkable new water-repellent material.

Already, General Electric engineers have assisted the Sonotone Corporation in working out a DRI-FILM moisture-proofing treatment for hearing aid electron tubes. Radio, television, and public address systems will want its protection, too. But that's only the beginning.

DRI-FILM is fine for glass—textiles—paper—ceramics—plastics—almost any type of material that must shed water quickly and withstand wide ranges of heat and cold.

DRI-FILM isn't the only product our new plant is going to make. Far from it. DRI-FILM has a lot of surprising relatives in the silicone family. There are silicone oils, silicone greases, silicone varnishes, silicone rubber products, and silicone insulating materials. The wonderful thing about them all is the way they can stand up against heat, cold, moisture, and chemicals. Undoubtedly, dozens of new silicone applications will develop as the products become more readily available.

During the war, General Electric's pilot plant turned out silicones in a variety of forms. But the quantities were limited. Soon, with our new plant, we'll be able to produce silicone products by the tank car and by the ton—enough to meet your production needs.

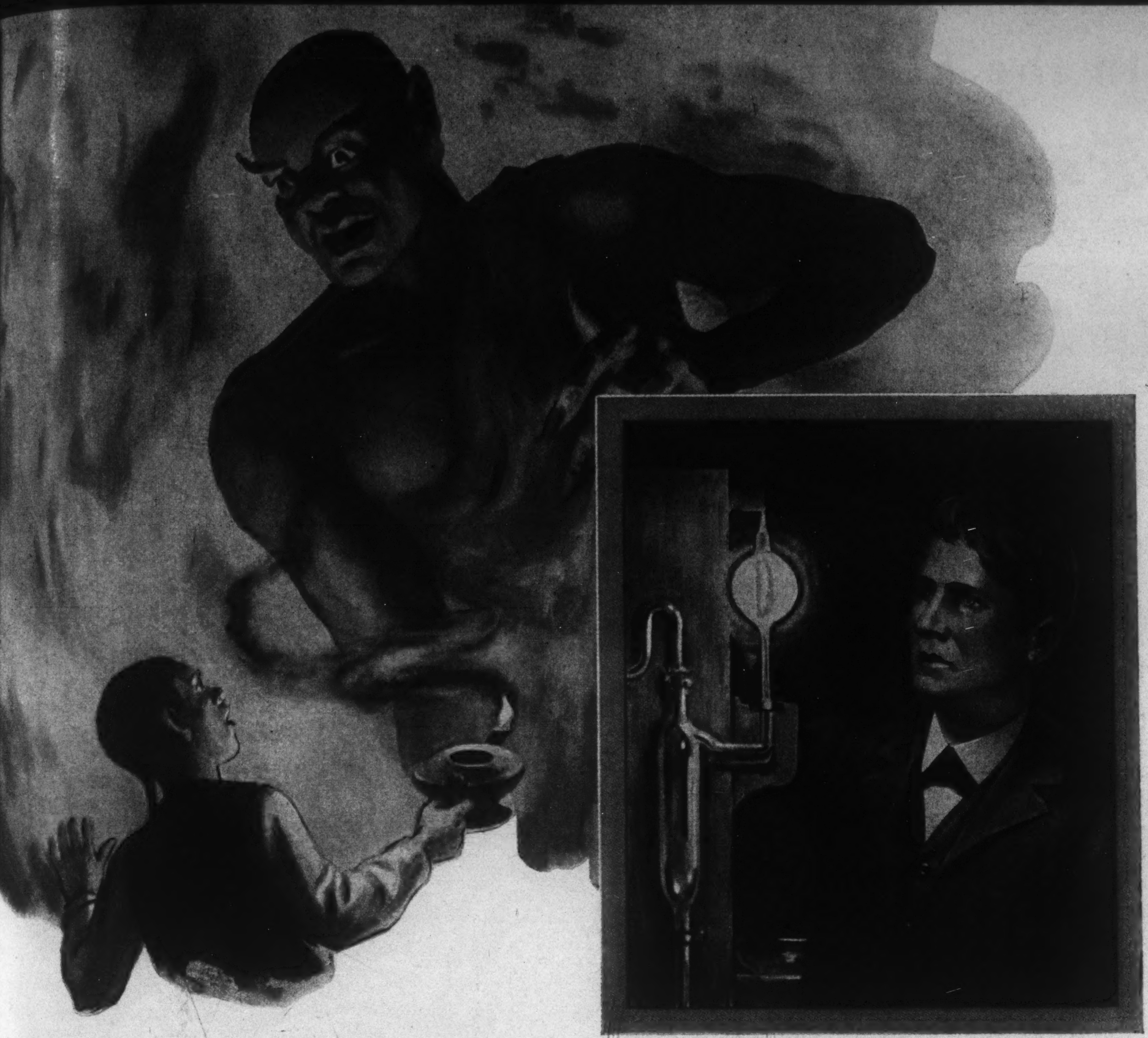
When will that day come? It should be early in 1947. While we're getting ready to make silicones, many manufacturers are getting ready to *use* them. Do you see possible uses for silicones in your production? For more information, consult General Electric. Write to the Chemical Department, General Electric Company, Schenectady 5, N. Y.

YOU'LL BE HEARING A LOT ABOUT

SILICONES

GENERAL ELECTRIC

CD46-S4



IT WAS EDISON, NOT ALADDIN WHO REALLY HAD THE LAMP!

"ALADDIN'S LAMP" made good reading but gave little illumination to a light-hungry world. It was the tiny glow of Edison's incandescent lamp that expanded into the radiance which floods the globe.

Hard on the heels of Edison's invention came the need for transmitting electricity, economically, over long distances. Thus, the development of alternating current in the 1880's enabled this young nation to set the pace in the whole realm of electricity. For here was an economical means of transmitting electrical energy at high voltages and with low losses—not only for light, but also for the heat and power on which the growth of industry thrived.

Then, as now, electricity and copper were inseparable... and The American Brass Company was already a leading supplier of copper, brass and bronze. Today, with more than a hundred years of manufacturing experience behind it, this Company continues its help in working out many of the metal problems peculiar to the electrical equipment and appliance industries... and to the fields of electric power generation, distribution and control.

46161

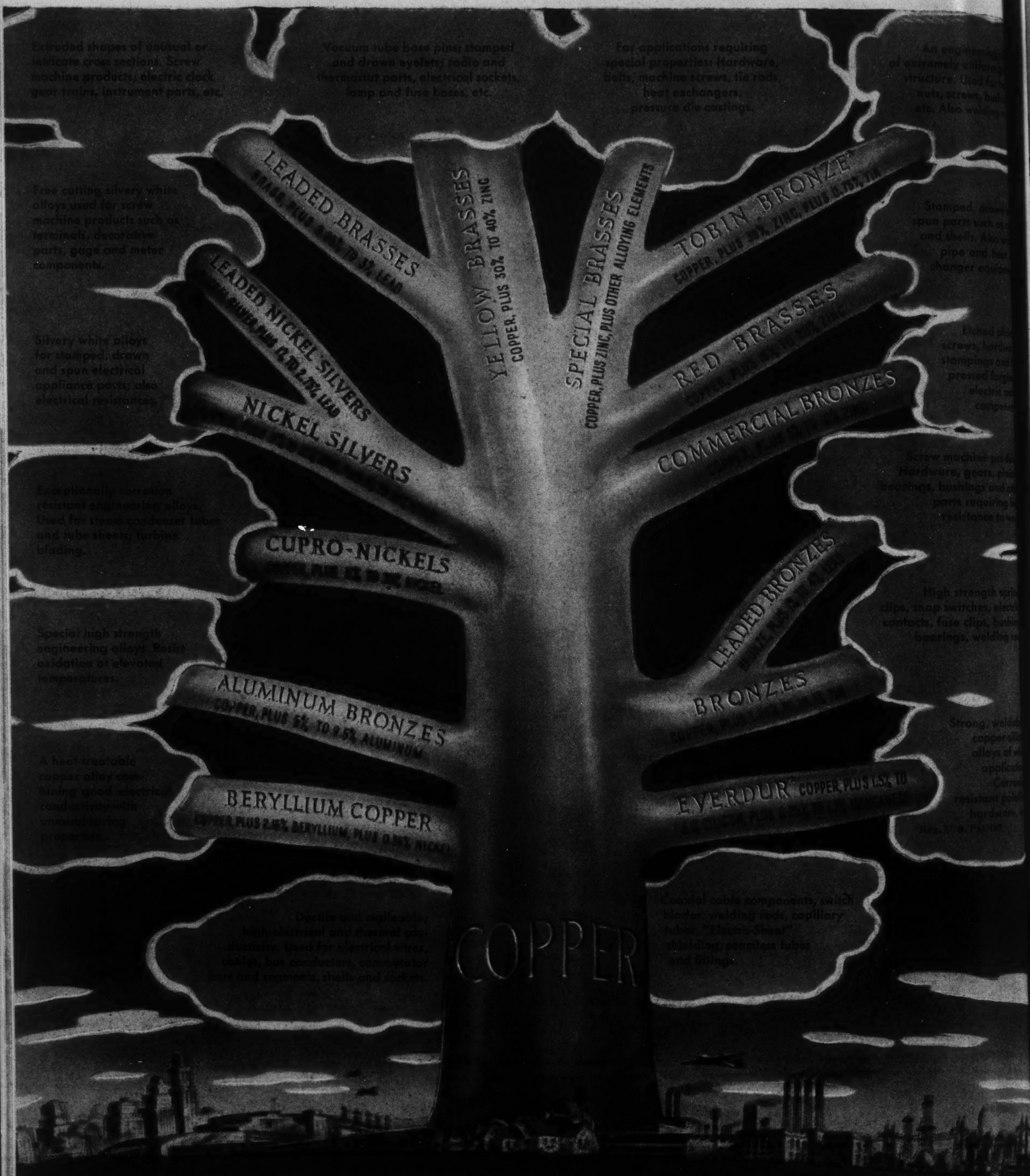
THE AMERICAN BRASS COMPANY
General Offices: **Waterbury 88, Connecticut**

ANACONDA
from mine to consumer

Anaconda Copper & Copper Alloys ⇨

In the Electrical Industry

Nothing serves like Copper and its Alloys



LEADED BRASSES
BRASS, PLUS 0.5% TO 3% LEAD
YELLOW BRASSES
COPPER, PLUS 30% TO 40% ZINC
SPECIAL BRASSES
COPPER, PLUS ZINC, PLUS OTHER ALLOYING ELEMENTS
TOBIN BRONZE*
COPPER, PLUS 39%, ZINC, PLUS 0.75% TIN
LEADED NICKEL SILVERS
NICKEL SILVER PLUS 1% TO 2.75% LEAD
RED BRASSES
NICKEL SILVERS
COMMERCIAL BRONZES
CUPRO-NICKELS
LEADED BRONZES
BRONZES
ALUMINUM BRONZES
COPPER, PLUS 5% TO 9.5% ALUMINUM
BERYLLIUM COPPER
COPPER, PLUS 2.15% BERYLLIUM, PLUS 0.35% NICKEL
EVERDUR* COPPER, PLUS 1.5% TO
COPPER

Extruded shapes of unusual or intricate cross sections. Screw machine products; electric clock gear trains, instrument parts, etc.

Vacuum tube base pins; stamped and drawn eyelets; radio and thermostat parts, electrical sockets, lamp and fuse bases, etc.

For applications requiring special properties: Hardware, bolts, machine screws, tie rods, heat exchangers, pressure die castings.

An engineering
of extremely uniform
structure. Used for
nuts, screws, bush
etc. Also welding

Free cutting silvery white alloys used for screw machine products such as terminals, decorative parts, gage and meter components.

Stamped, drawn
spun parts such as
and shells. Also
pipe and heat
changer equip

Silvery white alloys for stamped, drawn and spun electrical appliance parts; also electrical resistances.

Etched pla
screws, hardwa
stampings and
pressed forgin
electric mo
componen

Exceptionally corrosion resistant engineering alloys. Used for steam condenser tubes and tube sheets; turbine blading.

Screw machine produ
Hardware, gears, pinio
bearings, bushings and oth
parts requiring
resistance to we

Special high strength engineering alloys. Resist oxidation at elevated temperatures.

High strength spring
clips, snap switches, electri
contacts, fuse clips, bushi
bearings, welding ro

A heat-treatable copper alloy combining good electrical conductivity with unusual spring properties.

Strong, weldab
copper-silic
alloys of wi
applicati
Corros
resistant pole
hardware,
*Reg. U. S. Pat. Off.

Ductile and malleable; high electrical and thermal conductivity. Used for electrical wires, cables, bus conductors, commutator bars and segments, shells and sockets.

Coaxial cable components, switch blades, welding rods, capillary tubes, "Electro-Sheet" shielding, seamless tubes and fittings.

ANACONDA
from mine to consumer

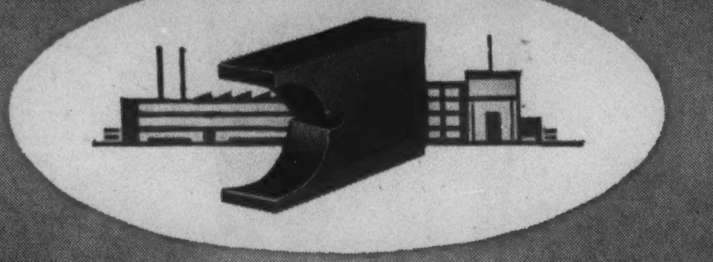
Made by THE AMERICAN BRASS COMPANY

General Offices: **Waterbury 88, Connecticut • Subsidiary of Anaconda Copper Mining Company**

In Canada: ANACONDA AMERICAN BRASS LTD., *New Toronto, Ont.*

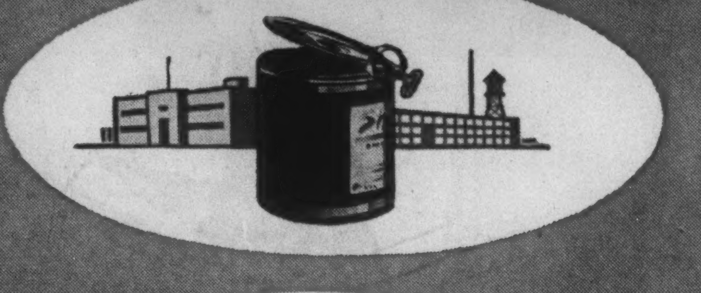
In Electric Motor Manufacture

Carboloy* work-supports make possible greater concentricity of commutators and quieter motors.



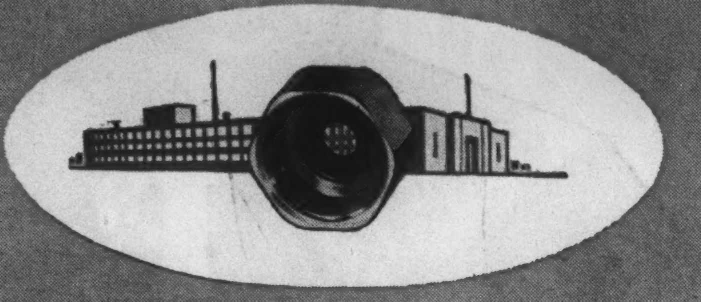
In Container Making

Carboloy* solved a problem of costly maintenance, by outlasting steel 35 to 1.



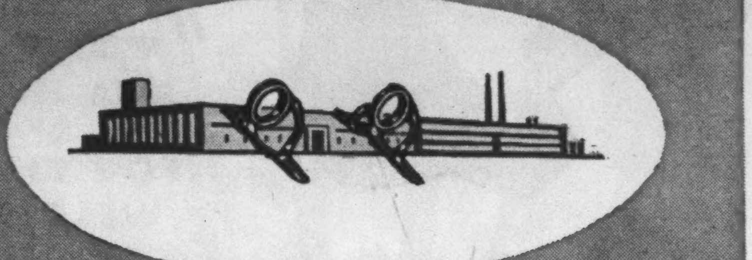
In a Farm Equipment Plant

Carboloy* showed the way to make spray discs last the life of the sprayer.



In the Sporting Goods Field

Carboloy* solved a troublesome line-guide problem (applicable to guide-wear problems in the textile field, carpet manufacture, etc.).



. . . And in hundreds of other applications, they're solving their product problems with

Carboloy,* the versatile metal

IT PAYS . . . to investigate Carboloy* Hard Metal, no matter how remote your product may seem from the realm of this versatile powdered metal. For Carboloy* Hard Metal is entering new fields every day. It is literally "working wonders" in such widely-differing fields as the manufacture of:

Spark Plugs—Flashlight Batteries—Buttons—
Hoists—Pens and Pencils—Cigars

. . . to name just a few. Tough jobs are being done easier and faster. Maintenance cost is being cut down. Parts life is being boosted as high as 35 times. Production increases up to 100 times are being recorded!

Carboloy* Hard Metal may similarly solve *your* problem. Write us today, briefly describing the application, and we will promptly send our recommendations.

Put this "Versatile Metal" To Work For You—
6 Useful Properties Combined in One Metal.

High Red Hardness • Extreme Density • High Abrasion Resistance • High Modulus of Elasticity • High Compressive Strength • Low Coefficient of Expansion and Contraction.

CARBOLOY*
TRADEMARK CEMENTED CARBIDE
HARD METAL

CARBOLOY COMPANY, Inc., 11111 E. 8 Mile Road
Detroit 32, Michigan

CHICAGO • CLEVELAND • DETROIT • HOUSTON • LOS ANGELES • MILWAUKEE
NEWARK • PHILADELPHIA • PITTSBURGH • THOMASTON

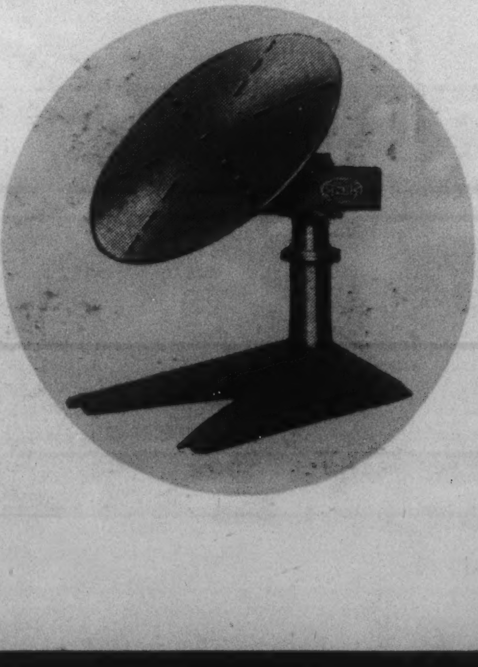
P&H
"FW"... "DRAG IT!"
FOR FILLET WELDING

FOR GREATER WELDING SPEED

"FW" speeds welding and reduces operator fatigue because it "rides" on its coating. You strike an arc — and "drag it" lightly over the metal. It's that simple!

"FW" fills in the long gap between class E-6012 and E-6020 electrodes. It has the same qualities for poor fit-up as 6012 — the fast freezing, and ability to weld out of position. Yet it gives you the speed, ease and finished weld appearance of the best in the 6020 class.

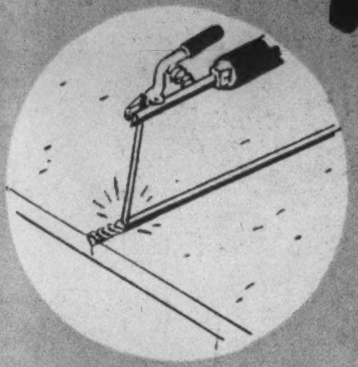
P&H designed this electrode for today's fillet welding requirements. It's for AC or DC welding of medium and mild steels. Try "FW" on your work. Call your P&H representative today for demonstration.



P&H Welding Positioners

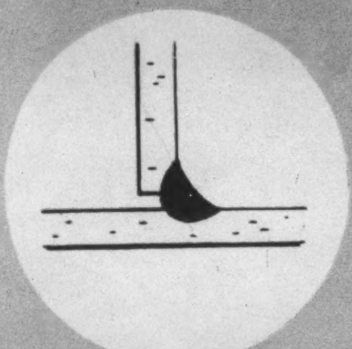
Reduce your welding costs by permitting operators to raise, tilt or rotate the work for fast, easy downhand welding. Use larger electrodes for faster deposition of weld metal. P&H Welding Positioners are available up to 36,000-pound capacity. Ask for literature. Below 2500-pound capacity, Bulletin P2-1; above, Bulletin P1.

for Faster Welding



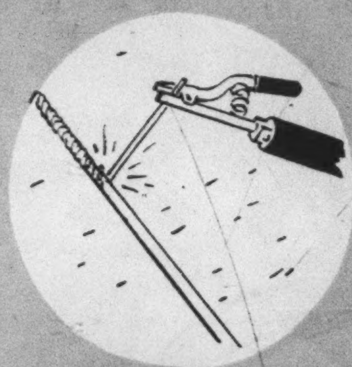
JUST "DRAG" THE ELECTRODE

Welding is easier with "FW". No arc gap to worry about. Electrode actually "rides" on its coating. Fatigue is reduced. Operators weld better and faster.



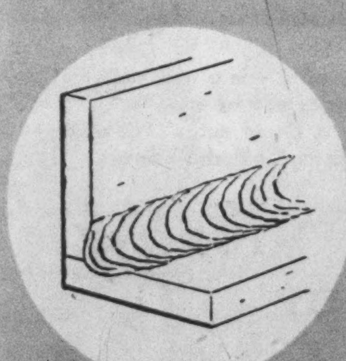
FAST FREEZING

Poor fit-ups are no problem with "FW". Its fast freezing means better results. You get fine concave fillets—smooth appearance.



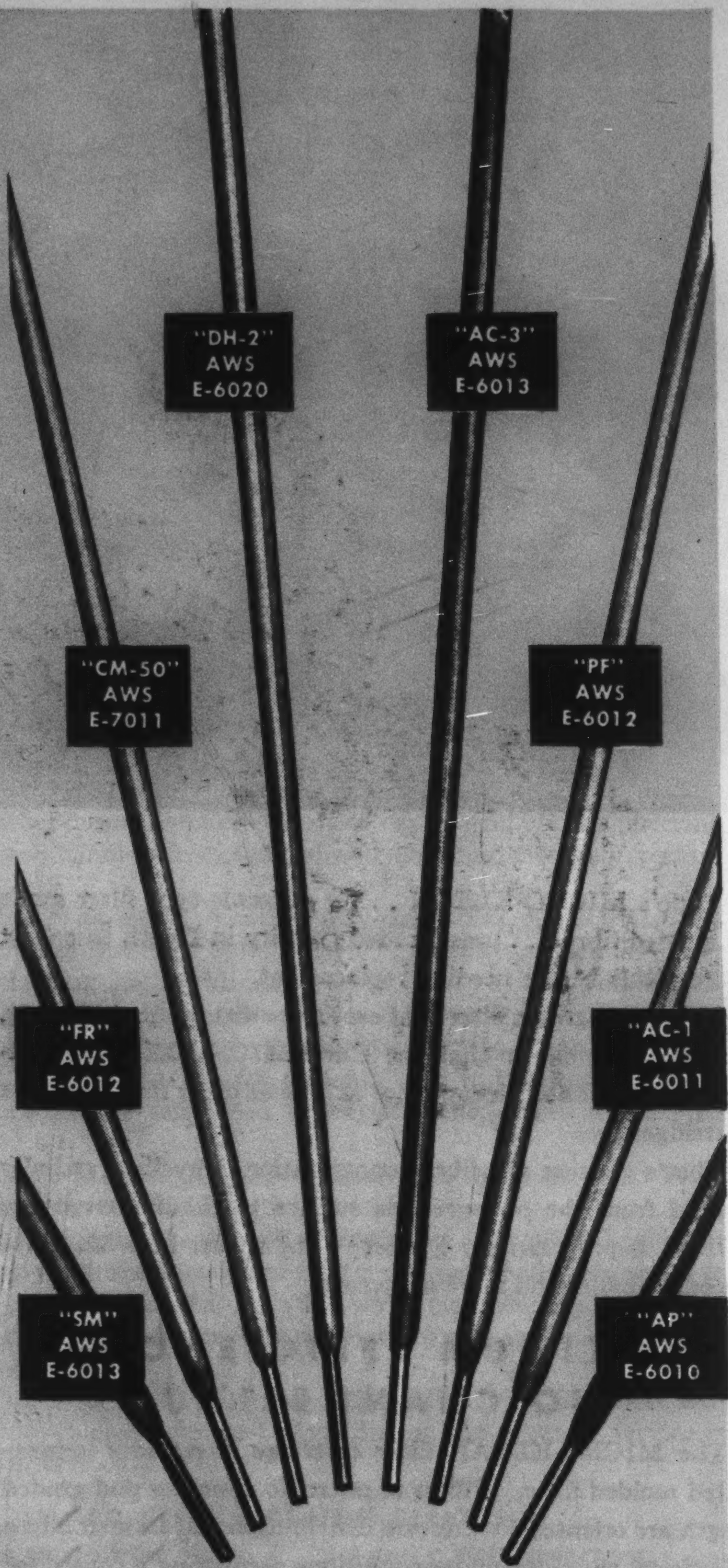
OUT-OF-POSITION WELDING

Although "FW" is a downhand electrode, it can also be used for out-of-position welding by experienced operators. This saves more time — is another reason for its wide acceptance.



GOOD APPEARANCE

You get smooth, uniform welds with "FW" — even over irregular and poor-fit joints. It's the ideal electrode for machine bases, farm and road machinery, structural work, etc.



P&H ELECTRODES FOR *EVERY* REQUIREMENT

Whatever your welding needs, you can choose the correct types and sizes from the complete P&H line. Above are shown a few of the P&H mild steel group. A complete line for welding stainless and alloy steels, as well as for hard surfacing, is also available.

CALL YOUR P&H REPRESENTATIVE

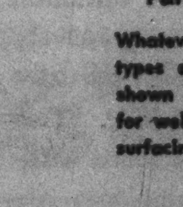
P&H makes a production-proved electrode for every welding requirement: for all mild, alloy and stainless steel applications cast iron and for building up and hard surfacing.

P&H

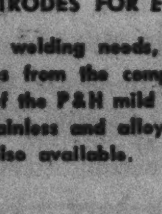
WELDING ELECTRODES
4550 W. National Ave.
Milwaukee 14, Wisconsin

HARNISCHFEGER CORPORATION
WELDING ELECTRODES • MOTORS • HOISTS P&H ELECTRIC CRANES • ARC WELDERS • EXCAVATORS

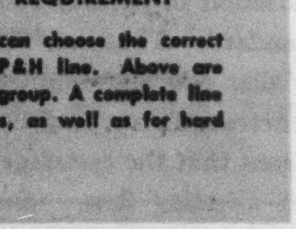
AMERICA'S MOST COMPLETE WELDING SERVICE



DC WELDERS

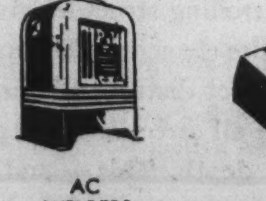


AC WELDERS

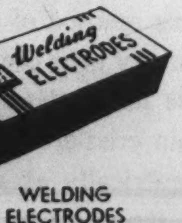


WELDING ELECTRODES

WELDING POSITIONERS



WELDING PRODUCTION CONTROL SYSTEMS



ELECTRIC HOISTS

A NEW FILTER . . .
A NEW PRINCIPLE

to cut filtering replacement costs in half

Cuno MICRO-KLEAN filters are available in a wide range of housing designs and replacement cartridges can be supplied in practically any desired length. Loosening a single nut disassembles housing for easy cartridge replacement on model illustrated.

Cuno's MICRO-KLEAN . . . a micronic-type filter made of molded fibre . . . uses Graded Density in Depth to collect more solids before needing replacement.

Here's a micronic filter that eats more dirt without choking.

Experience shows that the Cuno MICRO-KLEAN cartridge maintains efficiency twice as long as other micronic-type cartridges.

That's because the fibre concentration, travelling radially inward from the pressure-side surface to the discharge-side surface, is progressively greater — the spaces between fibres become smaller and more numerous.

MAXIMUM EFFICIENCY— NO CHANNELING

The MICRO-KLEAN filter cartridge is resinous-impregnated molded fibre. Fibres of micronic diameter and graded length are oriented for uniform distribution and formed into a cylindrical cartridge,under conditions permitting a controlled variation of density radially to a pre-determined optimum standard. Thus, as the fluid flows through progressively smaller and more numerous interstices, the foreign particles penetrate to varying depths according to their size. This means that the cartridge can accommodate more solids without affecting flow — and will have a longer efficiency life before needing replacement.

This method of controlling structure gives the same range of density over the entire element. The natural arrangement of the fibre mixture is not disturbed laterally, so the fibres remain criss-crossed in all directions and porosity is uniform concentrically at any depth. This — and the fact that the fibre structure is preserved by resinous impregnation and polymerization — means maximum efficiency for every unit of filter area — and a *sure* protection against channeling.

Cartridges now available will remove all particles larger than 25 microns and the greatest proportion of particles down to 1 micron. (Coarser and finer filtration will be available soon). Use coupon to write for information in more detail.

WHAT MAKES MICRO-KLEAN LAST LONGER?

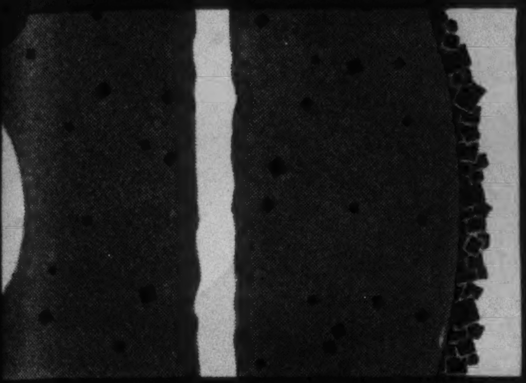
A special method of "felting" and impregnating micronic fibres, developed by Cuno engineers using the resources of a nationally known research foundation, has produced a depth-type micronic cartridge with *exclusive* advantages:

1. Graded Density in Depth, controlled concentrically and radially. Spaces between fibres become progressively smaller and more numerous approaching discharge surface. Smaller particles penetrate to varying depths — no sealing-over of inlet surface.

2. Resinous impregnated — each micronic fibre bonded in position — absolute protection against channeling, rupturing, shrinking or distortion.

How MICRO-KLEAN Compares with Other Depth-Type Filters

1



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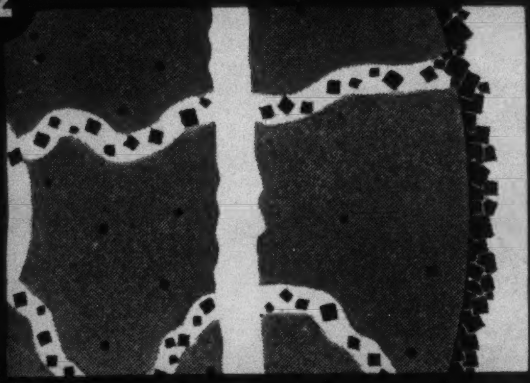

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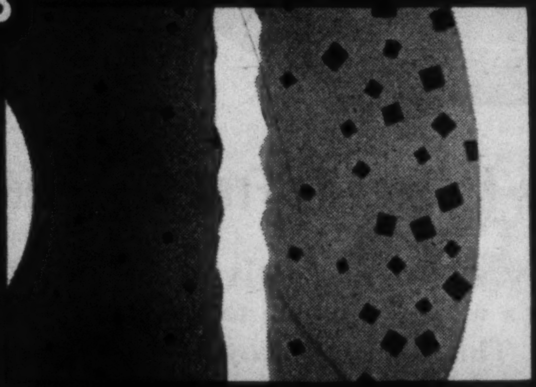
3



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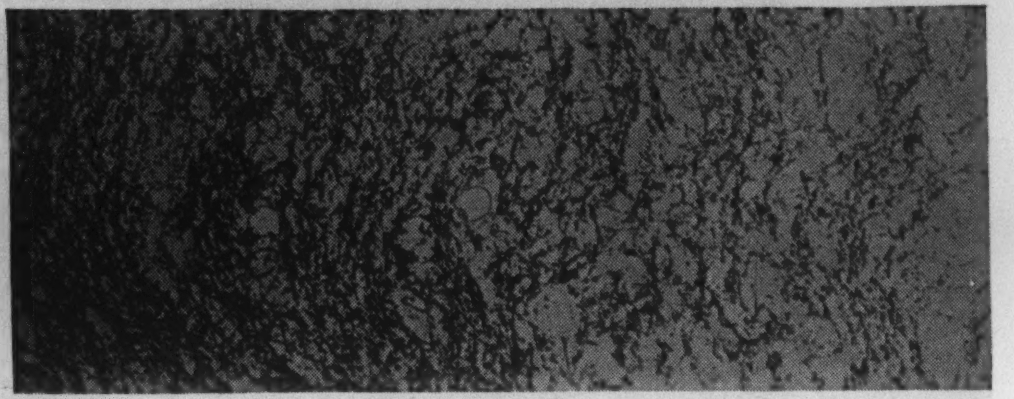
CUNO

GRADED DENSITY IN DEPTH



Photomicrograph shows progressively greater fibre density encountered by fluid as it passes from pressure surface (right) through depth of element to discharge surface (left).

MICRO-KLEAN *greatly extends the range of applications for Cuno Fluid-Conditioning*

With MICRO-KLEAN, Cuno — whose filters are used more by Industry than any other brand — offers you the equipment and engineering service to help you handle successfully almost any fluid-cleaning requirement.

Cuno's famous all-metal continuously-cleanable AUTO-KLEAN removes all particles down to .0035″ from practically any fluids other than those containing highly abrasive solids. Cuno's wire-wound self-cleaning FLO-KLEAN is recommended for fluids containing large proportions of highly abrasive solids — mill river water, etc. Cuno's specially-designed COOLANT-KLEAN is for coolants used in precision grinding. Cuno's air filters remove unwanted solids, entrained moisture and oil from compressed air.

And now Cuno's MICRO-KLEAN extends the range of Cuno Fluid Conditioning down to micronic particles!

Cuno maintains a competent staff of engineers in twenty key cities across the country, who will cooperate with you personally and bring to you the active participation of Cuno's factory engineering staff. Sample fluid tests are conducted, either in our laboratory or in the field, upon arrangement.

Meanwhile, have us send you more information on Cuno MICRO-KLEAN. For convenience, use the coupon, listing the types of service in which you are interested.

MICRO-KLEAN HOUSING DESIGNS

Complete range from ⅜″ to 4″ inlet and outlet connections, handling up to 300 gpm. Other sizes available soon.

MICRO-KLEAN CARTRIDGE SIZES

1″ I. D. and 2¾″ O. D. standard at present. Standard lengths: 4″, 8″, 10″. Special lengths available for built-in installations or for housings already in service.

CUNO ENGINEERING CORPORATION
4517 South Vine Street, Meriden, Conn.

Please send me information on Micro-Klean Filter relative to the services checked.

- ☐ Lubricating Oil
- ☐ Hydraulic Oil
- ☐ Fuel Oil, Diesel
- ☐ Water and Water Solutions
- ☐ Compressed Air
- ☐ Acids
- ☐ Fuel Oil, burner (Domestic and industrial)

Send information on MICRO-KLEAN to handle the following: (Write any other fluid-cleaning problem here.)

....

NAME ....

COMPANY ....

ADDRESS ....

Your tooling costs can be cut
right now

Here's How To Get More Output Per Grind, Longer Life From Your Tools!

First: Your tooling costs drop with every extra piece your tools produce per grind, every extra hour they stay on the job. That's why it pays you to use the Carpenter Matched Set Method of tool steel selection. This tried and proved method enables you to know *in advance* what performance to expect from the tool steel you use. Quickly and easily, it helps you select the tool steel best suited for the job. The result is longer tool life, more output per grind—lower tooling costs!

Second: For additional help in getting the kind of tool performance you want, get in touch with your nearby Carpenter representative. From the very start of your tooling job to its completion, he can give you all the information you need to put the Matched Set Method to work in your plant. So contact your Carpenter representative—just call your nearby Carpenter Warehouse or Distributor, today.

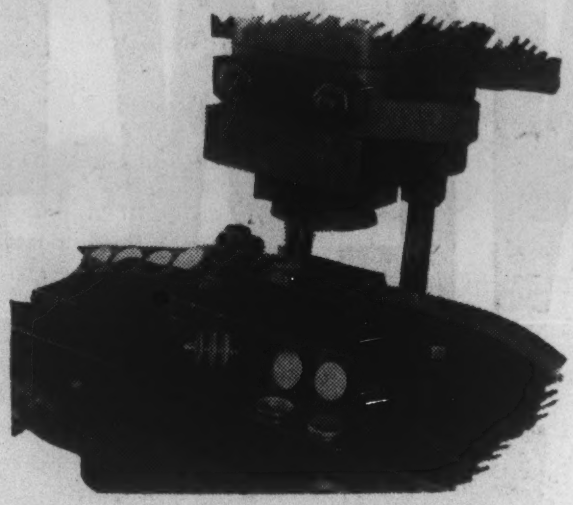
The Standard Tool Steels of Industry

THE CARPENTER STEEL COMPANY, 135 W. Bern Street, Reading, Pa.

Use the Matched Set Method for Results Like This:

Hours of Machine Down-time Eliminated Per Week: 11!

Extra Pieces Produced Per Grind: 550,000!



the Job: Blanking and forming Thermostat Diaphragms from .008" thick phosphor spring bronze.

the Problem: The nature of the material required tools with exceptionally sharp cutting edges. With the steel previously used, tools required too frequent regrinding and each time they were reground, 1½ hours of productive machine time were lost.

the Results: The tool maker, using the Matched Set Method, went to Carpenter *Hampden* (Oil-Wear) for greater wear resistance. The new *Hampden* punch eliminated *11 hours* of machine down-time each week and produced *550,000 additional* diaphragms per grind!

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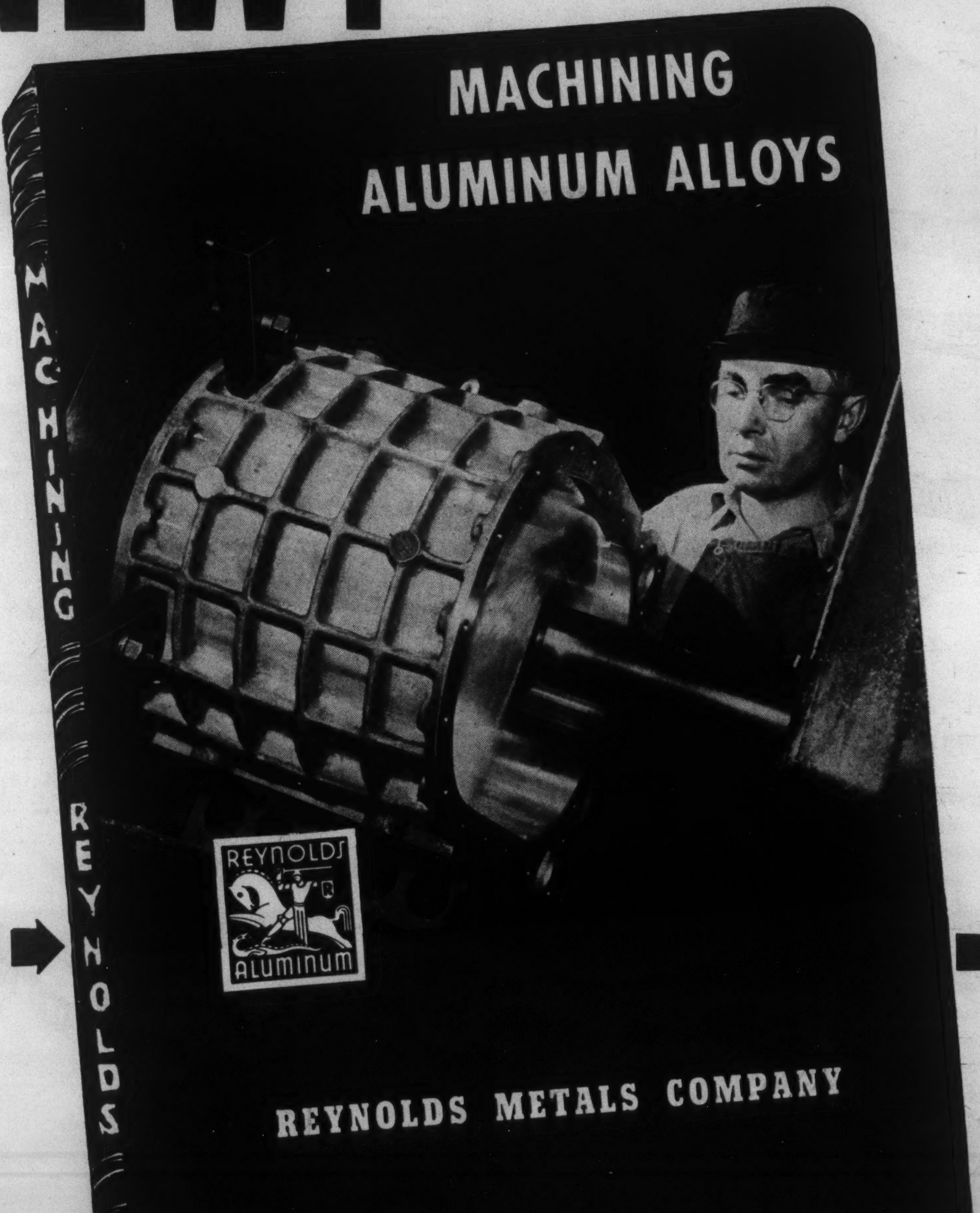
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manual on "MACHINING ALUMINUM ALLOYS"

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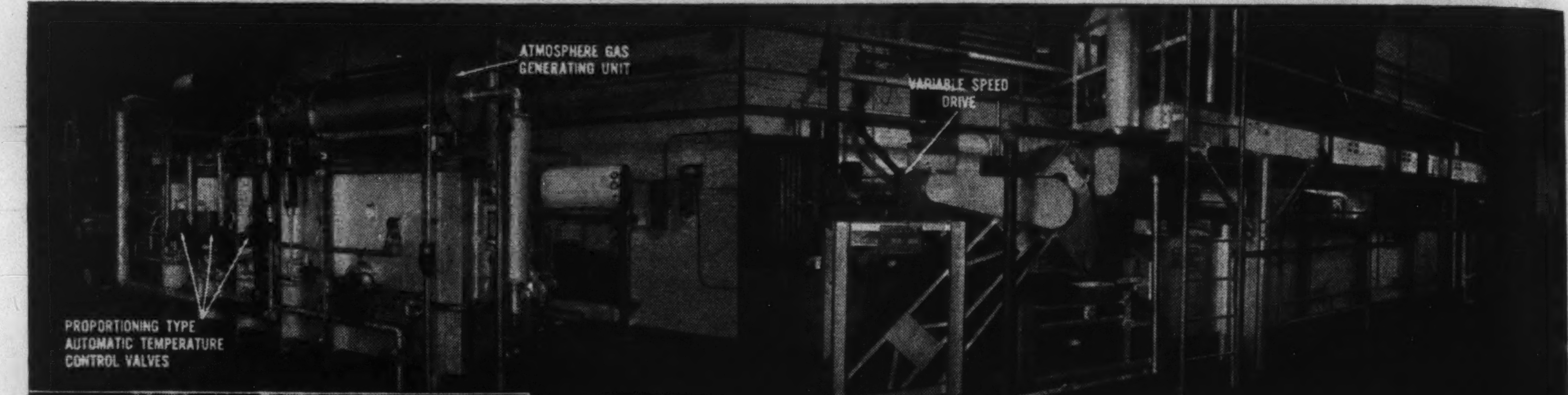
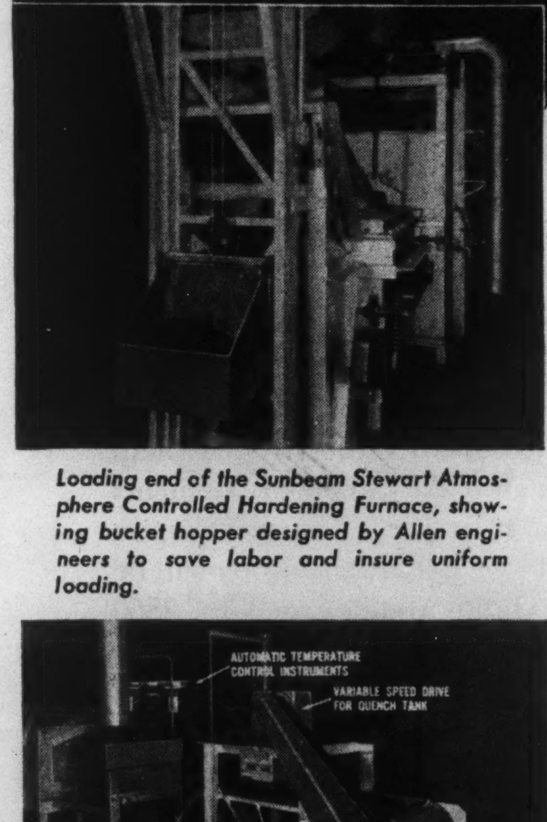
For HEAT TREATING HEX-SOCKET SCREWS, PLUGS, PINS and EXTENSIONS

at the Allen Manufacturing Company, Hartford, Conn.


ATMOSPHERE GAS GENERATING UNIT
VARIABLE SPEED DRIVE
PROPORTIONING TYPE AUTOMATIC TEMPERATURE CONTROL VALVES
COVERED QUENCH TANK

New Sunbeam Stewart Fully Automatic and Completely Atmosphere Controlled Continuous Hardening, and Tempering Installation at the Allen Manufacturing Company. This furnace does work that formerly required six rotary furnaces . . . eliminates the expensive degreasing operation between hardening and tempering.



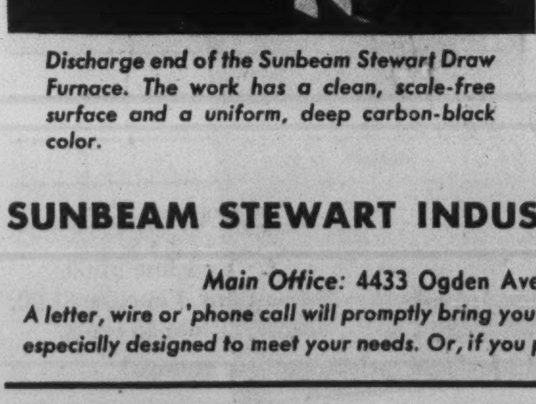
Loading end of the Sunbeam Stewart Atmosphere Controlled Hardening Furnace, showing bucket hopper designed by Allen engineers to save labor and insure uniform loading.

For the important job of securing hard and tough structure together with a uniform deep carbon black color for their famous Hex-Socket screws, the Allen Manufacturing Company chose a Sunbeam Stewart Fully Automatic and Completely Atmosphere Controlled Continuous Hardening, and Tempering Furnace Unit.

This Sunbeam Stewart installation has simplified Allen's heat treating process. It has replaced a gang of rotary furnaces and overcome an expensive degreasing operation between hardening and tempering.

Allen Hex-Socket screws, etc., are conveyed through the Sunbeam Stewart Atmosphere Controlled Hardening Furnace. The load then drops into the conveyorized Quench tank. Next, a conveyor carries the load through the Sunbeam Stewart Atmosphere Controlled Draw Furnace. The load now drops into a second quench tank, and another conveyor carries it to the discharge. These Sunbeam Stewart furnaces are designed to operate on manufactured gas and have a capacity of 800 lbs. per hour. All fuel, air, cooling liquids and the furnace atmosphere are under automatic control.

This installation is typical of the industrial furnaces Sunbeam Stewart engineers are building every day to meet the specified requirements of manufacturers all over the continent. In addition, Sunbeam Stewart builds a full line of standard furnaces.


AUTOMATIC TEMPERATURE CONTROL INSTRUMENTS
VARIABLE SPEED DRIVE FOR QUENCH TANK
DRAINAGE AREA
QUENCH TANK AND DISCHARGE CONVEYOR

Discharge end of the Sunbeam Stewart Draw Furnace. The work has a clean, scale-free surface and a uniform, deep carbon-black color.

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A letter, wire or 'phone call will promptly bring you information and details on SUNBEAM STEWART furnaces, either units for which plans are now ready or units especially designed to meet your needs. Or, if you prefer, a SUNBEAM STEWART engineer will be glad to call and discuss your heat treating problems with you.

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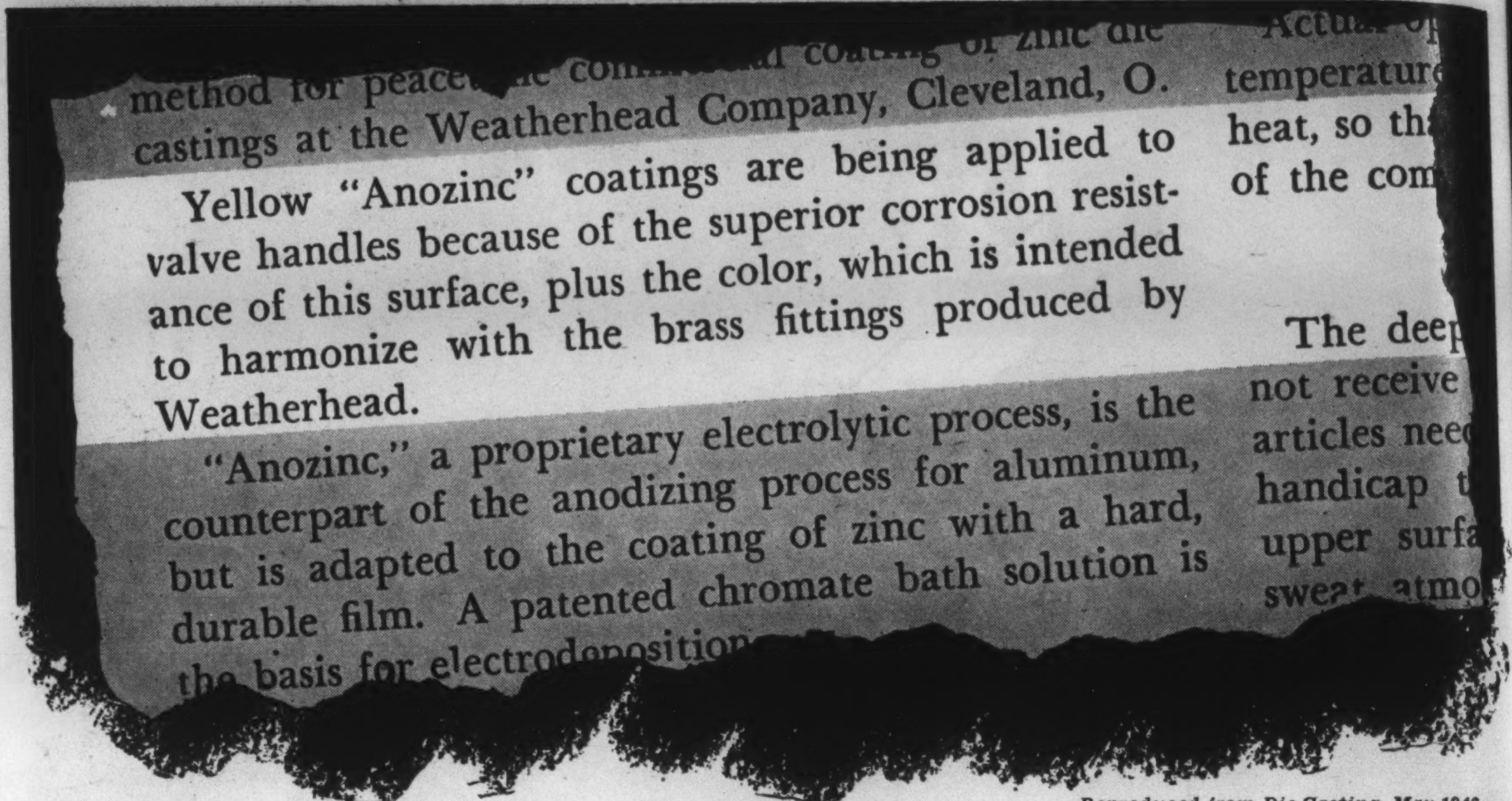

method for peacetime commercial coating of zinc die castings at the Weatherhead Company, Cleveland, O.

Yellow "Anozinc" coatings are being applied to valve handles because of the superior corrosion resistance of this surface, plus the color, which is intended to harmonize with the brass fittings produced by Weatherhead.

"Anozinc," a proprietary electrolytic process, is the counterpart of the anodizing process for aluminum, but is adapted to the coating of zinc with a hard, durable film. A patented chromate bath solution is the basis for electrodeposition

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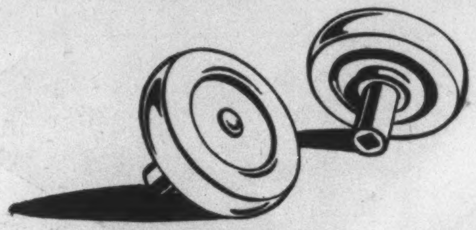
Reproduced from Die Casting, May 1946

HERE'S HOW ANOZINC* MAKES THESE VALVE HANDLES LAST LONGER—AND LOOK BETTER



THE PROBLEM in turning out these zinc die cast valve handles was to select a protective coating that would resist severe corrosive conditions. Weatherhead engineers specified Anozinc because it had proved itself in a 200-hour salt spray test. Not only did Anozinc provide positive protection—it matched the color of the brass fitting as well.

It makes no difference whether your product is zinc die cast or zinc plated. Anozinc protects *any* zinc surface from corrosion—and at the same time, primes it for paint or lacquer, or provides an attractive final finish in itself. If you'd like to see further evidence of what Anozinc can do, we'll be glad to process test pieces for you. Write your nearest Unichrome office for details.

*Anozinc is a trade-mark registered in the U. S. Patent Office by United Chromium, Incorporated, for chemical compounds for use in anodizing metals.

FEATURES THAT STAND OUT

- **EXCELLENT CORROSION RESISTANCE**—Anozinc surfaces greatly increase rust resistance and retard formation of white zinc corrosion products.
- **LOW COST**—Anozinc salts are moderately priced. Solutions are stable and easily maintained.
- **FAST SIMPLE PROCEDURE**—Operated at room temperature in unlined steel tanks. Finish produced in about 3 minutes. Parts can be handled immediately, while wet—no special drying required.
- **UNIFORM PROTECTION**—Precision process assures uniformity of penetration and degree of corrosion resistance.
- **THREE ATTRACTIVE FINISHES**—Black, brassy yellow or clear—a different solution being used for each.

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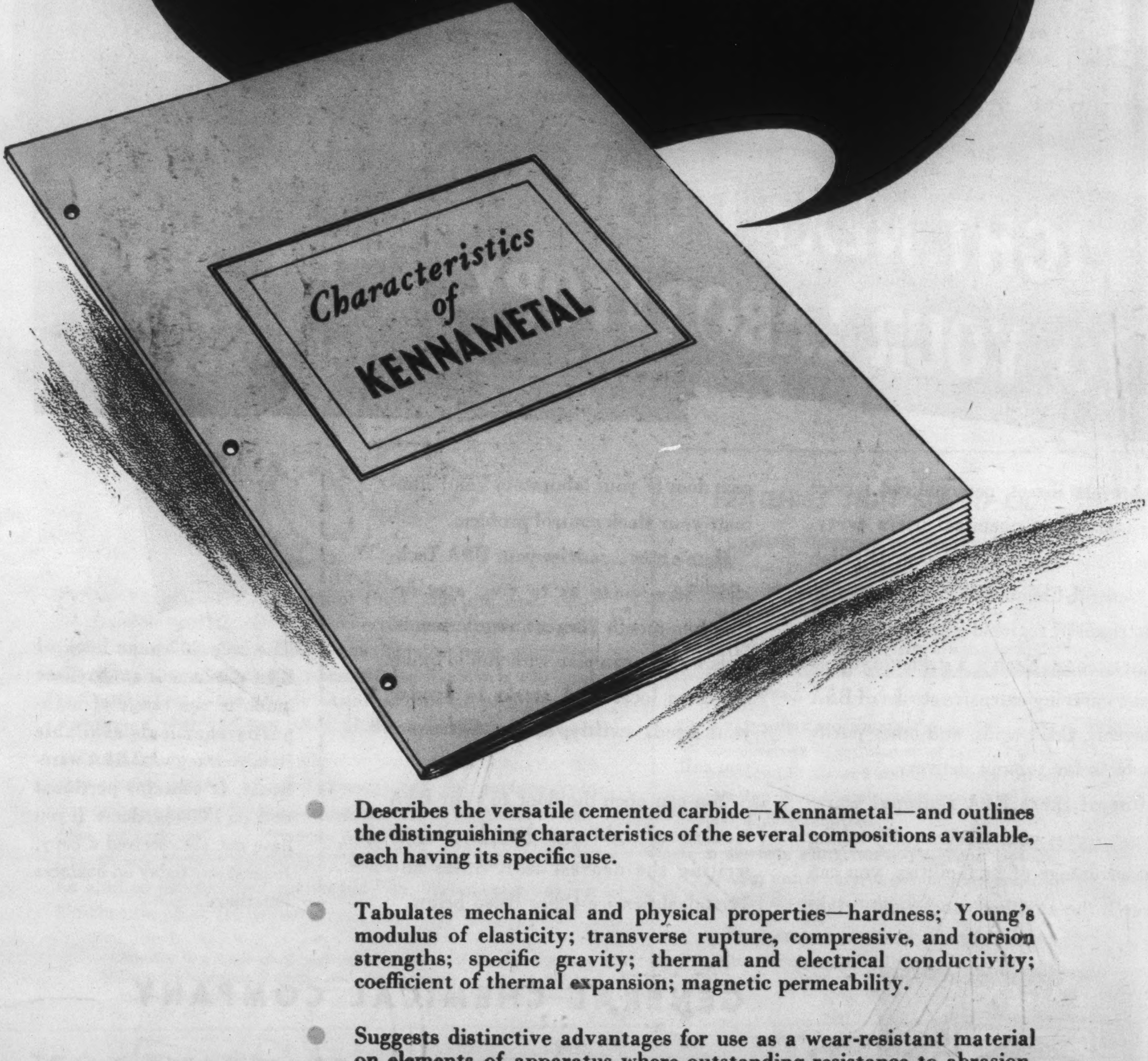

- Describes the versatile cemented carbide—Kennametal—and outlines the distinguishing characteristics of the several compositions available, each having its specific use.

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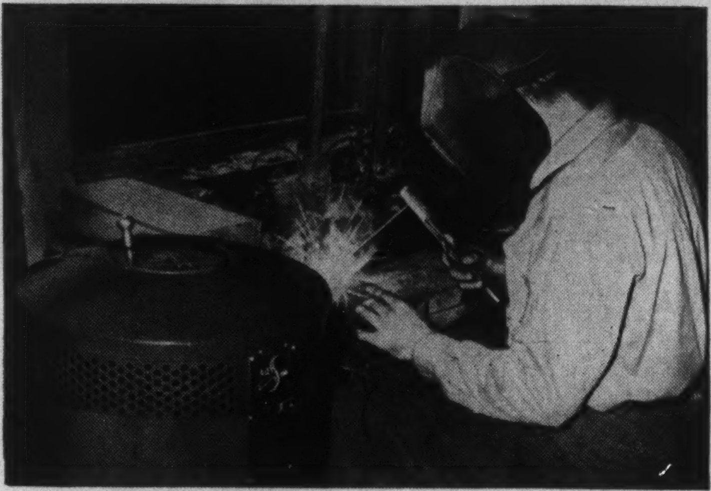


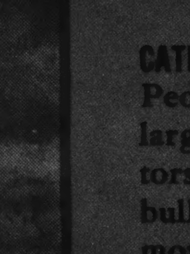
Welding church candlestick holders in H. Wolter and Sons shop

CATERPILLAR TRACTOR COMPANY, Peoria, Ill., one of the world's largest manufacturers of tractors for farm and industry, bulldozers, and other earth-moving machinery, employs SMITHway Electrodes for many production operations. Like manufacturers everywhere, "Caterpillar" knows the proof of SMITHway Electrodes is in production—and in *service.*

"Caterpillar" Diesel D7 tractor

SMITHway *Certified* Welding Electrodes—Made *by* Welders... *for* Welders

Through Leading Distributors Everywhere



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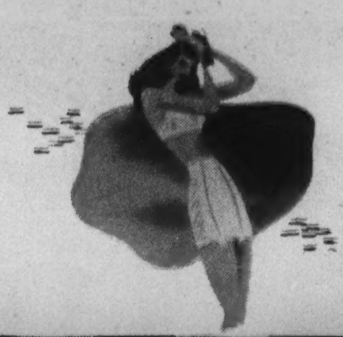

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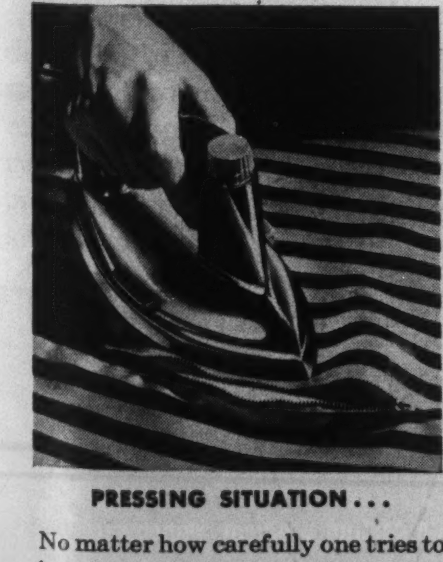
Slips of NYLON...

Another new product from a Du Pont Plastic

AND NOW — ZIPPERS OF NYLON TOO!

Strong enough for girdles, light enough for filmy silk . . . dry-cleaning, laundering do not harm it



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No matter how carefully one tries to iron "around" a slide fastener, the hot iron is apt to slip—and with some other plastic fasteners this can be very harmful. Du Pont nylon, however, stands heat up to 350° F. This is sufficient to iron any fabric, including cotton.

Any day now, your wife or daughter will be buying a dress equipped with a slide fastener of Du Pont nylon. And this will interest you as a manufacturer—no matter how remote from the dress business your product may be.

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For nylon is not harmed by laundering or by dry-cleaning. It is light in weight, yet produces an especially strong slide fastener because it forms a permanent bond with the cloth tape. Most important, nylon is not damaged by ironing, and it will not rust.

A nylon zipper...a polythene watch strap...a baby's bassinet of "Lucite"... these and countless other diversified products have this one thing in common: *In each a manufacturer was enabled to bring out a new or improved product, because of his knowledge of the properties of a Du Pont plastic.* E. I. du Pont de Nemours & Co., (Inc.), Plastics Dept., Room 4112, Arlington, N. J.

The nylon slide fastener shown is manufactured by Waldes Koh-I-Noor, Inc., Long Island City, N. Y.

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BETTER THINGS FOR BETTER LIVING
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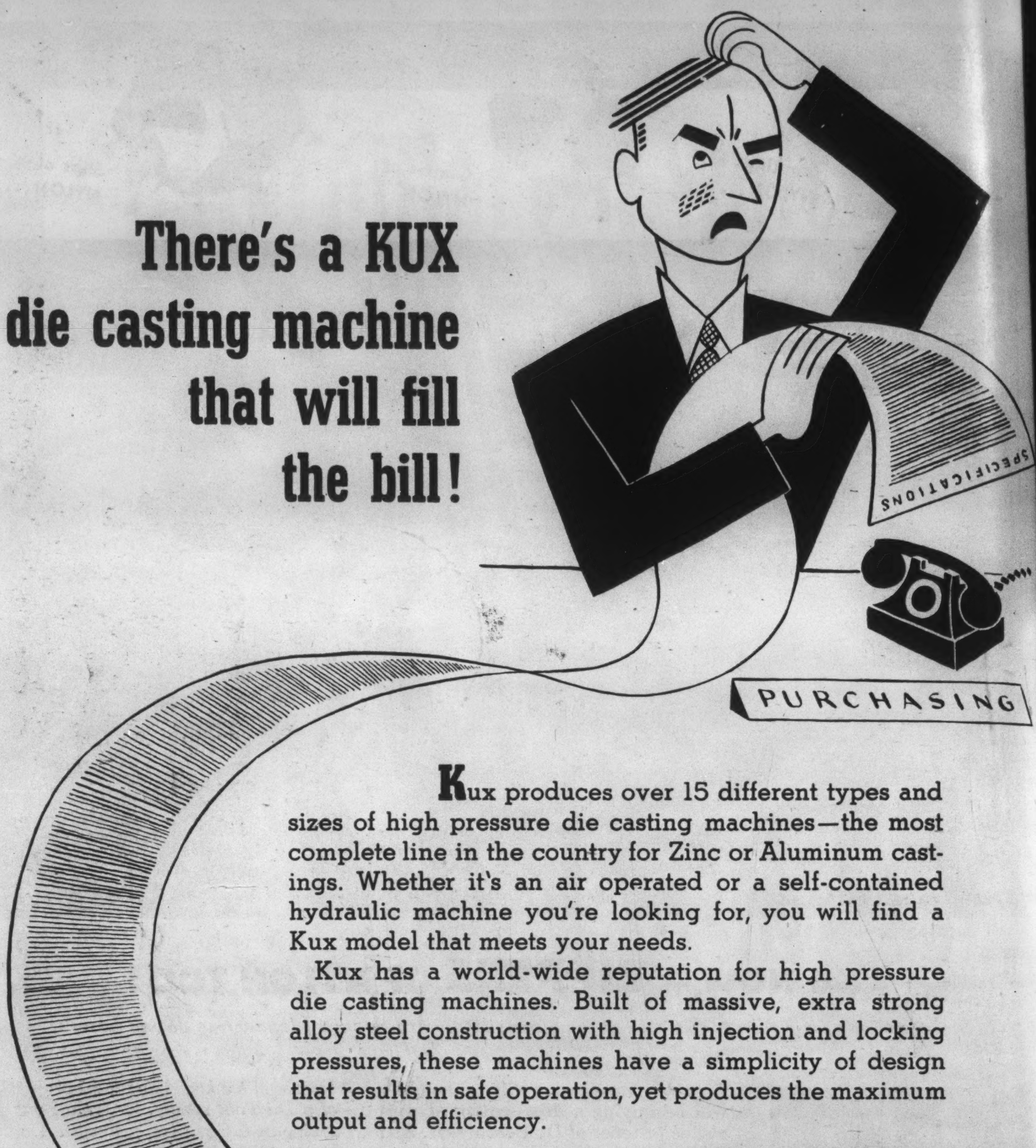
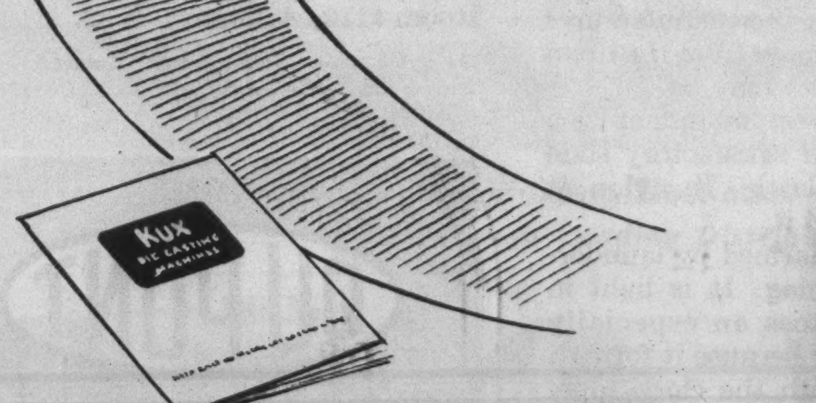
There's a KUX die casting machine that will fill the bill!



Kux produces over 15 different types and sizes of high pressure die casting machines—the most complete line in the country for Zinc or Aluminum castings. Whether it's an air operated or a self-contained hydraulic machine you're looking for, you will find a Kux model that meets your needs.

Kux has a world-wide reputation for high pressure die casting machines. Built of massive, extra strong alloy steel construction with high injection and locking pressures, these machines have a simplicity of design that results in safe operation, yet produces the maximum output and efficiency.

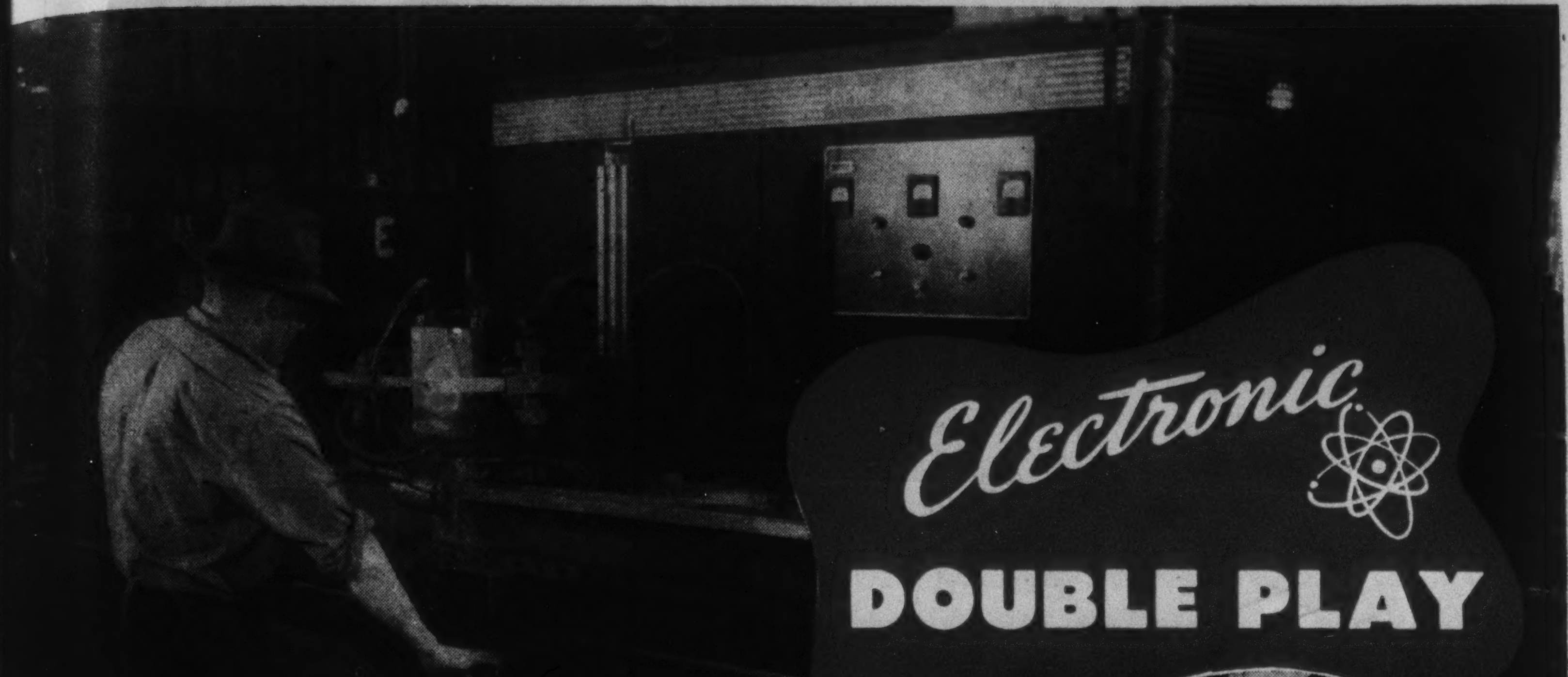


Write Dept. 27 for this complete catalogue which contains full specifications and illustrates the many models which are being used by die casting producers all over the country.

When you have a die casting problem, remember

KUX machine co.

2924-44 W. Harrison St., Chicago 24, Illinois

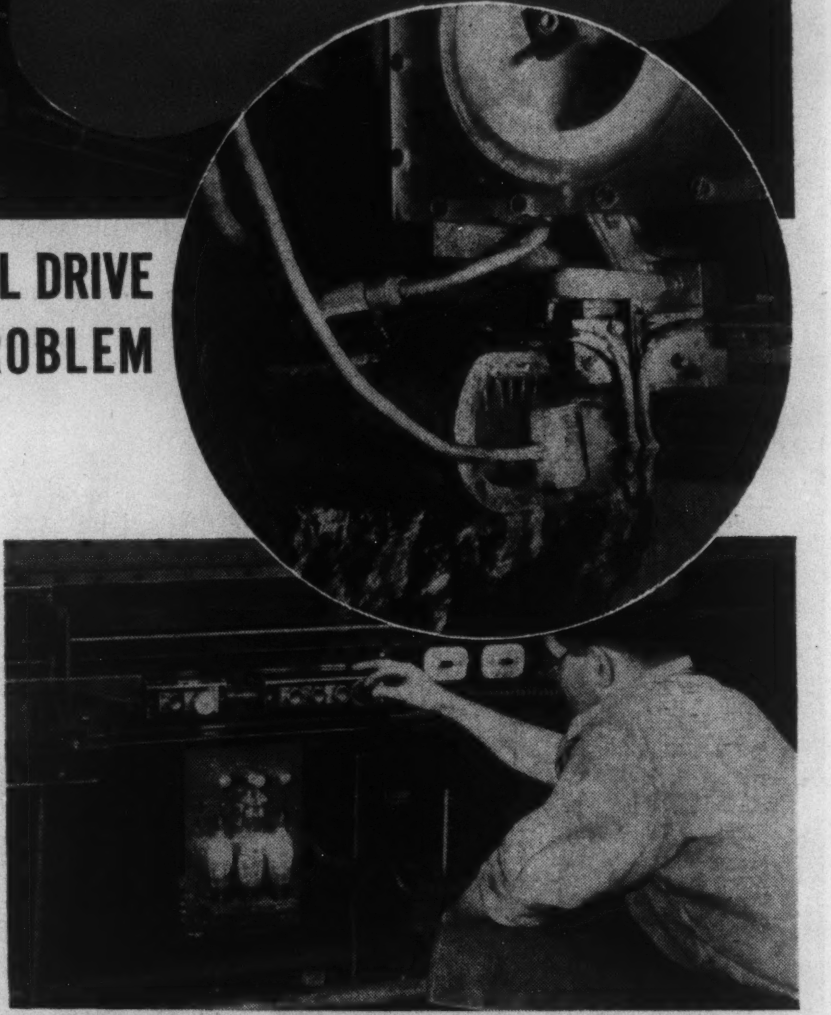


G-E ELECTRONIC HEATER and THY-MO-TROL DRIVE SOLVE DIFFICULT DIE-HARDENING PROBLEM

How could the wearing surfaces of brake dies measuring up to 20 feet in length be efficiently hardened? Because of the distortion difficulties due to the length of the dies, furnace hardening and salt-bath hardening were out of the question.—This was the problem referred to G-E engineers by the Dreis & Krump Manufacturing Company in Chicago.

After carefully analyzing the production requirements of this company, G-E heating specialists scored an electronic double play. The dies to be hardened are passed under the work coil of a G-E electronic heater by a G-E Thy-mo-trol-controlled carriage. Since the Thy-mo-trol drive equipment is connected into the plate circuit of the electronic heater, the speed of the carriage varies directly with the power output of the electronic heater. Thus, with this controlled carriage-speed and power-output ratio, the brake dies are hardened uniformly, with close depth control, and with minimum distortion. Also, Dreis & Krump are now producing a better product at a cost considerably lower than that of any other previous method of die hardening.

Perhaps your heat-treating operations could be similarly improved in speed, quality, and economy with G-E equipment and expert heat engineering. We shall be glad to furnish you with detailed information on G-E electronic heaters and to make specific recommendations for their application to your individual requirements. Just fill out and mail the coupon.



Brake-die wearing surface (above), passing under G-E electronic heater's work coil and into quench shoe for hardening.

Detail of electronic Thy-mo-trol equipment (below), for regulating carriage speed with heater's power output.

Apparatus Dept., Sec. L675-145
General Electric Company, Schenectady 5, N. Y.

My heat-treating problem is..........

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..........Please have a G-E heating specialist get in touch with me.
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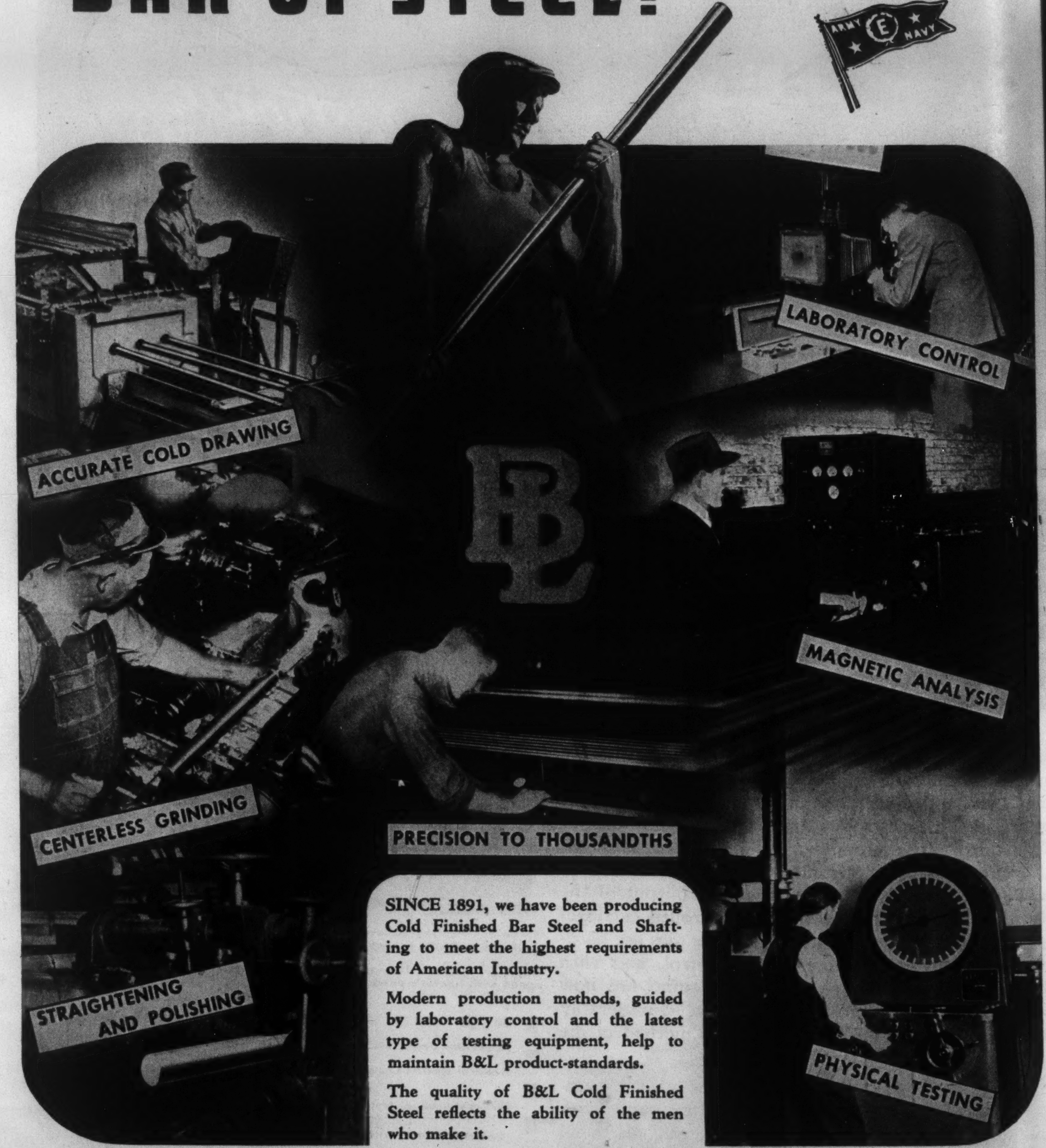
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Eighteen years ago Austenal Laboratories originated the MICROCAST PROCESS for precision casting of intricate dental appliances to close tolerances using Vitallium*. In 1936, production on surgical appliances and jewelry specialties was pioneered by Austenal—another contribution by MICROCAST.

Another significant development was the application of the MICROCAST PROCESS to the production of turbo-supercharger blades which were produced by the millions during the war period.

This pioneering record of achievement is the reason why manufacturers are looking to Austenal and the MICROCAST PROCESS for the practical solution to intricate casting problems where close tolerances and high production are important. Perhaps this experience can help you, too.

INDUSTRIES NOW USING MICROCAST

Austenal is now producing quantity castings from a fraction of an ounce up to a pound for the following industries: Aircraft, Automotive, Bottle Cap, Business Machine, Dairy, Electrical, Hearing Aid, Heating, Phonograph, Photographic, Printing, Radio and Sewing Machine.

More complete information on MICROCAST is contained in a new booklet published by the Austenal Laboratories, Inc., originators of the MICROCAST PROCESS. This valuable new booklet is fully illustrated and describes many industrial applications for MICROCASTINGS as well as giving a step by step description of the process itself. Write for your copy today.

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Steel Coal Cars
Metal Siding
Gas Heaters
Pipe Lines
Manifolds
Ash Cans
Pottery
Stoves
Tile

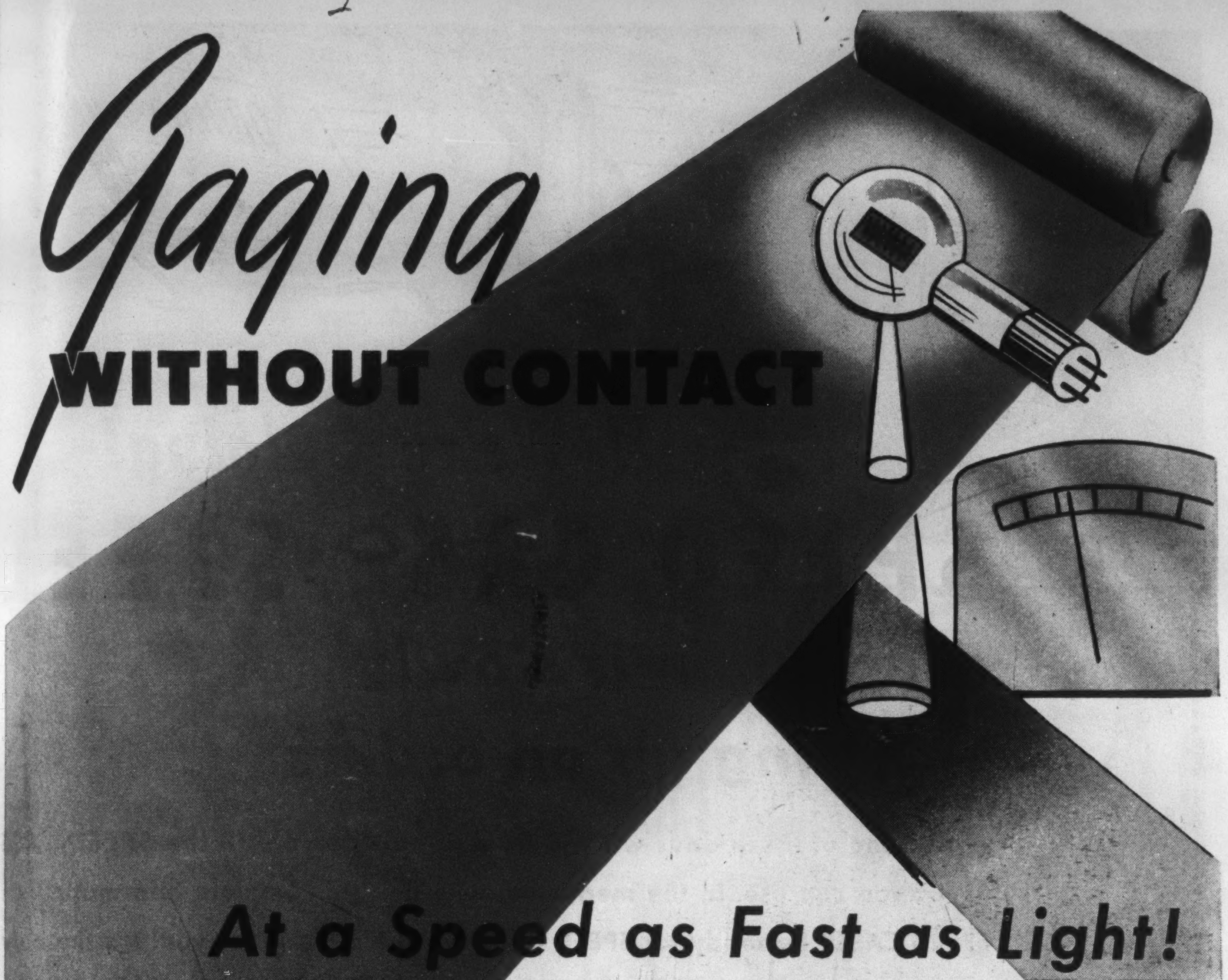
- ECONOMICAL
- DURABLE
- INORGANIC

We invite metal products manufacturers to submit articles to our laboratory to be KAYKOTED and returned to them with a complete report. Laboratory samples should not be larger than 12"x12"x48".

Spray it...
PROTECTION AGAINST CORROSION
KAYKOTE
LOW TEMPERATURE CERAMIC COATING
Dip it...

KAYKOTE DIVISION, KRAUS RESEARCH LABORATORIES, SPARKS, MD.
West Coast Distributor . . . INDUSTRIAL COATINGS COMPANY · 4031 Goodwin · Los Angeles 26, California · Tel. Chapman 5-2693

Gaging WITHOUT CONTACT



At a Speed as Fast as Light!

Hot sheets or strips of metal or foil flying from the rolls; paper emerging in a never-ending sheet; or the plastic or rubber blanket flowing from a calender, may be checked instantly for thickness, and this thickness controlled during the process, by the Sheffield Measuray.

Temperature of the material to be checked and its speed of movement do not affect the accuracy of the thickness check. Proximity of gaging head to material is not important—it can be as much as a foot or more distant, depending upon the application. Amplification and sensitivity are available in excess of any known industrial requirements without sacrifice in speed, range, or dependability. For instance, it is possible to amplify one per cent of the thickness of the stock being checked to extend over the full scale range.

The Measuray may be mounted on a production machine, or it may be used at the bench to measure stationary objects, especially those whose surfaces might be marred by a contact gage, or those of such resiliency that the contact gage measurements are not practicable.

See the Measuray demonstrated at the Sheffield plant in Dayton. Bring samples of work to be checked to see for yourself the savings in material and time, elimination of losses in destructive testing, and the increase in uniform quality which the Sheffield Measuray can bring you.

If a visit is not convenient, write us for detailed information. For an early installation, ask for a survey to be made in your plant by Sheffield engineers—no obligation on your part.

Write to Department H

2307

Real job security is only provided by plentiful incoming orders shipped at prices consumers can afford and want to pay . . . modern machine tools help make this possible.

METAL
CONGRESS
BOOTH H-234

THE SHEFFIELD CORPORATION

Dayton 1, Ohio, U.S.A.

MACHINE TOOLS • GAGES • MEASURING INSTRUMENTS • CONTRACT SERVICES

. . . Well! We're Gaining!

SPEED CASE STEEL

production is slowly creeping up on orders

—and one of these days we will be able to ship you all the SPEED CASE STEEL you can use. In the meantime, why not get complete information on SPEED CASE? Be ready for SPEED CASE when it's ready for you! It's the only steel possessing such high physicals, unusual ductility, AND cuts like A.I.S.I. B1113 at 250 S.F.P.M. It has a tensile strength of 80,000-90,000 PSI. It replaces B1112, B1113, C1117, C1118, C1019 and MACHINES 40% to 50% FASTER THAN ALL OTHER CASE CARBURIZING STEELS. Prepare NOW for SPEED CASE—

★ *Samples and an Expert to Show You How!*

Our Speed Case Production Expert will visit your plant after samples are sent you, and show you how to set up your machines and tools to INCREASE PRODUCTION 30 to 100% and still improve the quality of your product. It's a remarkable steel.

Tear off here ATTACH TO YOUR LETTERHEAD AND MAIL TO EITHER COMPANY BELOW

ACTUAL PHOTOGRAPH

Speed Case Steel (.20 carbon) 1 inch cold drawn bar tied in a knot, cold, without fracture.

Licensor

MONARCH STEEL COMPANY

HAMMOND · INDIANAPOLIS · CHICAGO

PECKOVER'S LTD., Toronto, Canadian Distributor

MANUFACTURERS OF A COMPLETE LINE OF COLD FINISHED CARBON AND ALLOY STEEL BARS

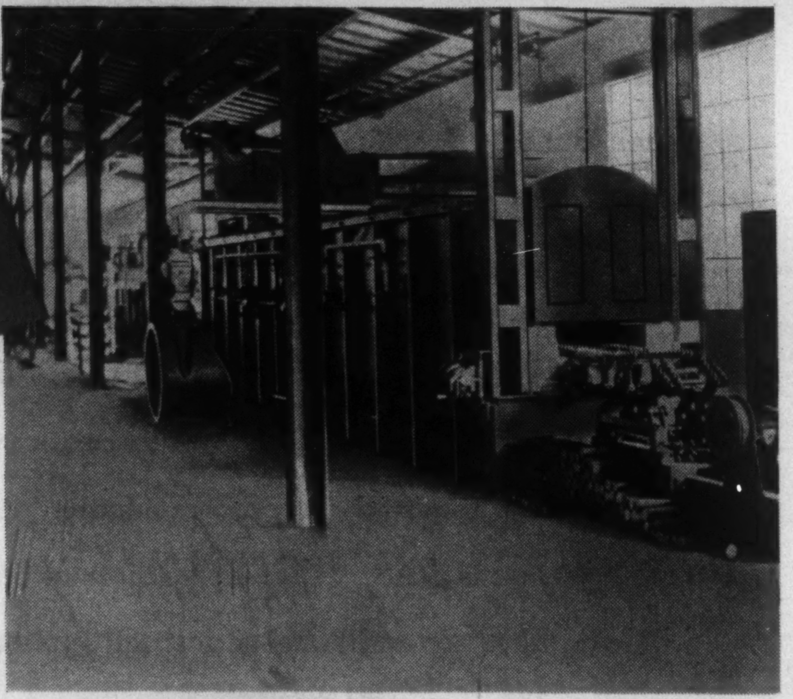
Licensee for Eastern States

THE FITZSIMONS COMPANY

YOUNGSTOWN, OHIO

TATE-JONES & CO., INC.

Since 1919



Established in 1898, Tate-Jones and the advancements in methods of heat treating with gas and oil have been parallel. To meet the rigorous demands requiring exact applications of heat with maximum efficiency in fuel and time, Tate-Jones has used Spencer Turbos since 1919.

Heat treating engineers of experience recommend Spencer Turbos primarily because of three accepted facts:

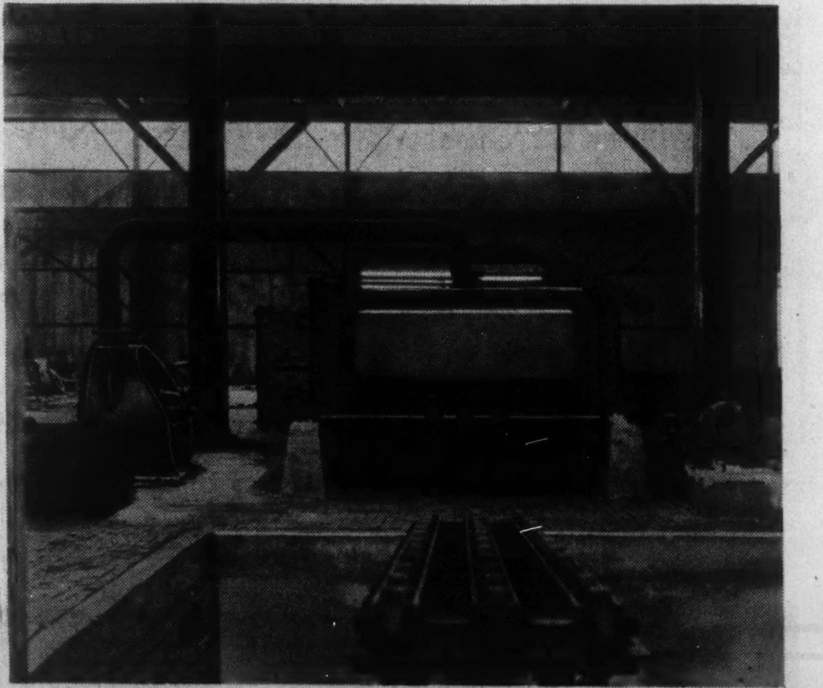
It is the simplest and sturdiest type of blower available for gas and oil-fired service.

It provides constant pressures automatically, without surges, without vibration or noise.

It maintains high efficiencies at all loads and therefore a high overall-operating efficiency.

Standard sizes from 35 to 20,000 c.ft.; 1/3 to 300 H.P.; 8 oz. to 5 lbs. Single or multi-stage, two or four gearing. Special gas-right and non-corrosive construction available.

Ask for the Turbo Data Book and Bulletins.



THE SPENCER TURBINE COMPANY
HARTFORD 6, CONN.

SPENCER HARTFORD TURBO-COMPRESSORS

280W

GAS

supplies

THE PRODUCTIVE FLAMES OF INDUSTRY

for

- core baking
- heat treating
- spheroidizing
- batch melting
- moisture control
- continuous copper brazing
- controlled atmosphere processing
- powder metal sintering

The *productive flames of industry* perform countless other duties. Practically every industrial heating requirement is a logical task for GAS, the versatile fuel, and for modern Gas-fired equipment.

FLEXIBILITY—CONTROLLABILITY—SPEED—UNIFORMITY—ECONOMY; wherever these qualities are required in process-heating, the dependable fuel is GAS. Inherent features of this fuel will suggest many additional industrial applications.

Day by day, successful applications of GAS eliminate production snarls in hundreds of manufacturing plants. Year after year, engineers and production managers specify GAS for increasing numbers of industrial heating installations. More and more the *"Trend is to GAS"* for all industrial heating.

Your local Gas Company solves industrial heating problems every day. Results of these studies will be helpful to you, too. An experienced Industrial Representative will recommend the proper use of GAS for your production process.

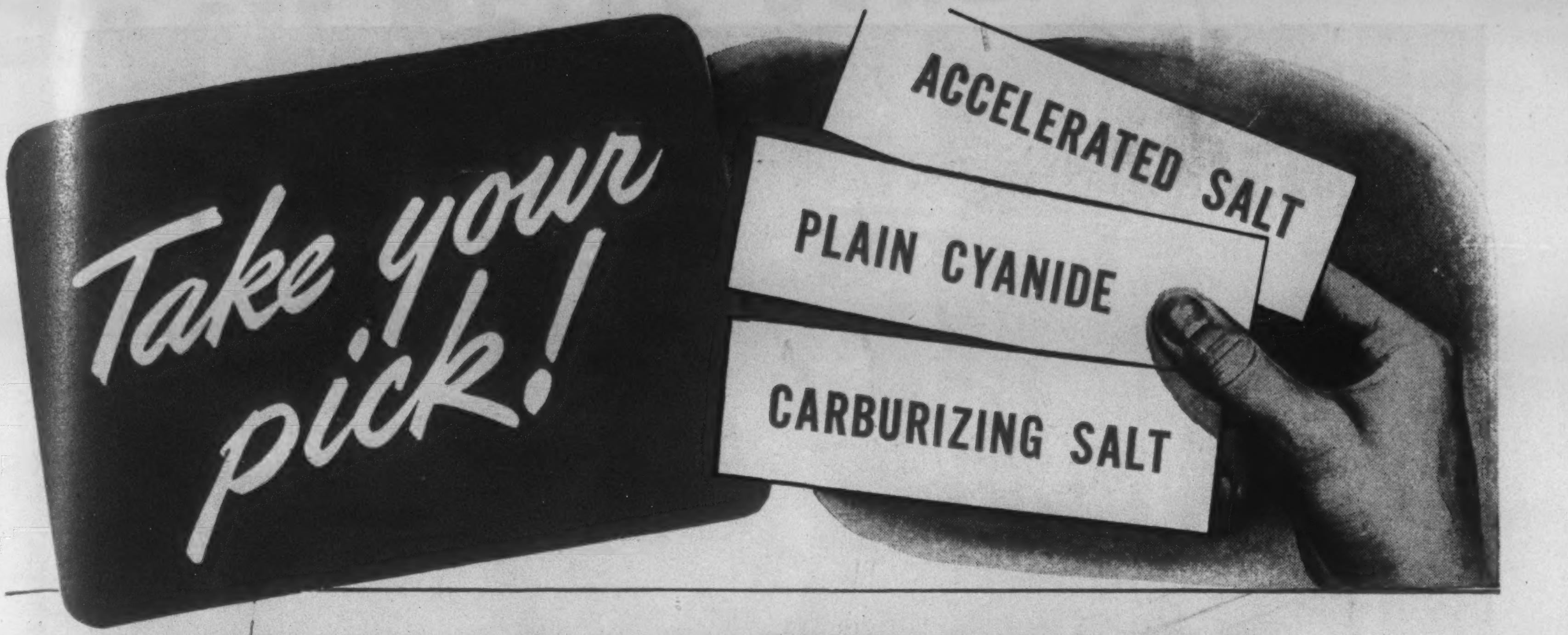
MORE AND MORE...

THE TREND IS TO GAS

FOR ALL INDUSTRIAL HEATING

AMERICAN GAS ASSOCIATION

420 LEXINGTON AVENUE, NEW YORK 17, N.Y.



There's a Du Pont Molten Salt Bath for Any Type of Case Hardening

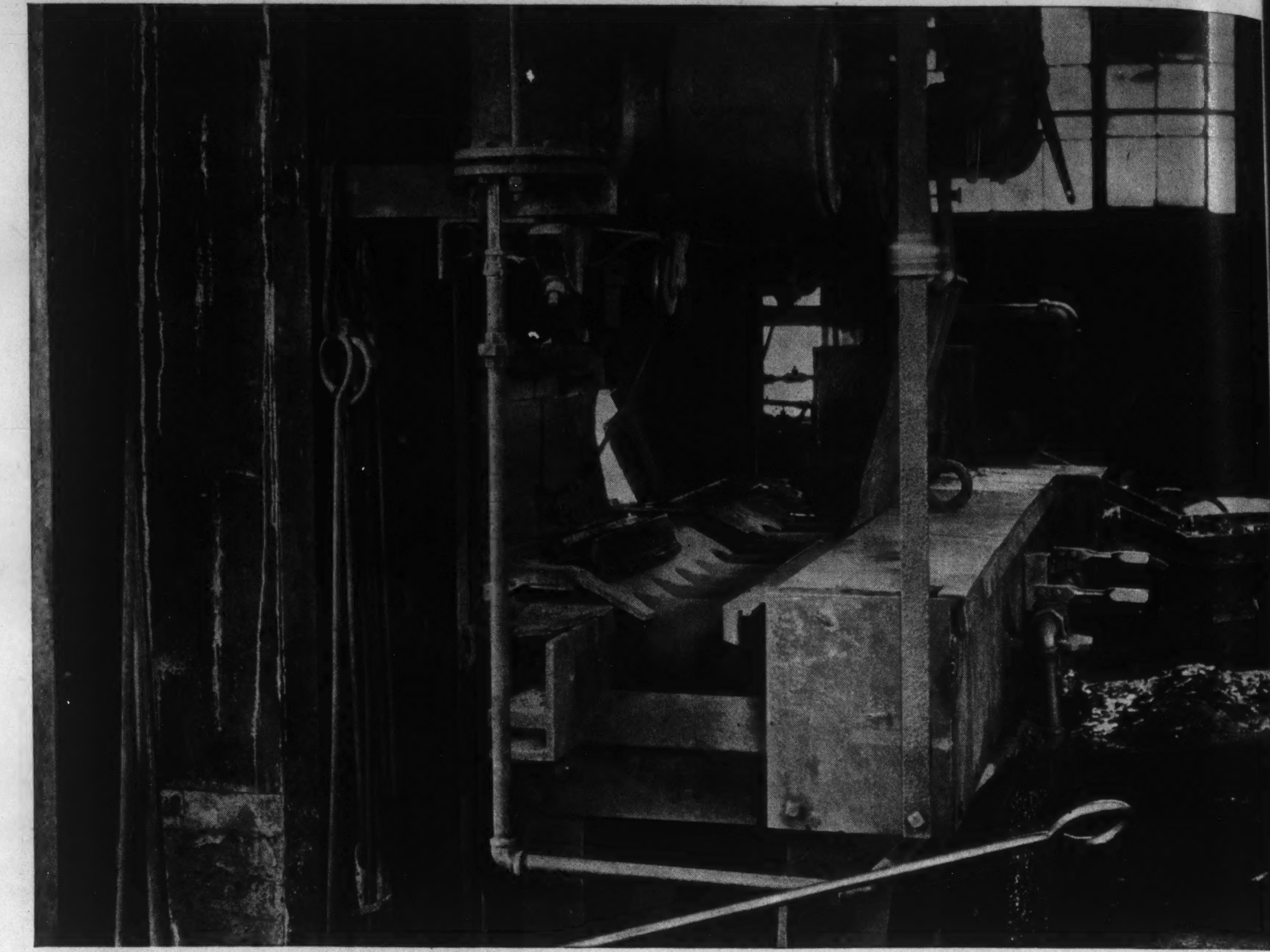
Case Depth Desired	Recommended Bath	Temp. °F	NaCN %	STARTING COMPOSITION	REPLENISHING COMPOSITION
0.003" to 0.010"	PLAIN CYANIDE	1400 to 1600	20-30	30 or 45% CYANIDE-CHLORIDE MIXTURE, "CYANEGG" and NaCl, and/or Na_2CO_3	45, 75 or 96% NaCN—depending on dragout loss
0.010" to 0.035"	DU PONT ACCELERATED SALT with Graphite Cover	1500 to 1650	18-22	ACCELERATED SALT or ⅓ HEAT TREATING SALT No. 6 plus ⅔ ACCELERATED SALT	ACCELERATED SALT
0.025" to 0.090"	DU PONT CARBURIZING SALT with Graphite Cover	1650 to 1750	8-12	⅓ CARBURIZING SALT plus ⅔ HEAT TREATING SALT No. 6	CARBURIZING SALT

EACH OF THESE BATHS is designed to produce cases of desired depth in the shortest possible time at the lowest possible cost. Yet they're but three of many Du Pont heat treating products that will return top production for you with maximum economy. Du Pont technical men will work with you in selecting the right materials to meet specific needs. For further details write: E. I. du Pont de Nemours & Co. (Inc.), Electrochemicals Department, Wilmington 98, Delaware.

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

DU PONT CYANIDES and SALTS
for Steel Treating



MULTIPLYING furnace production

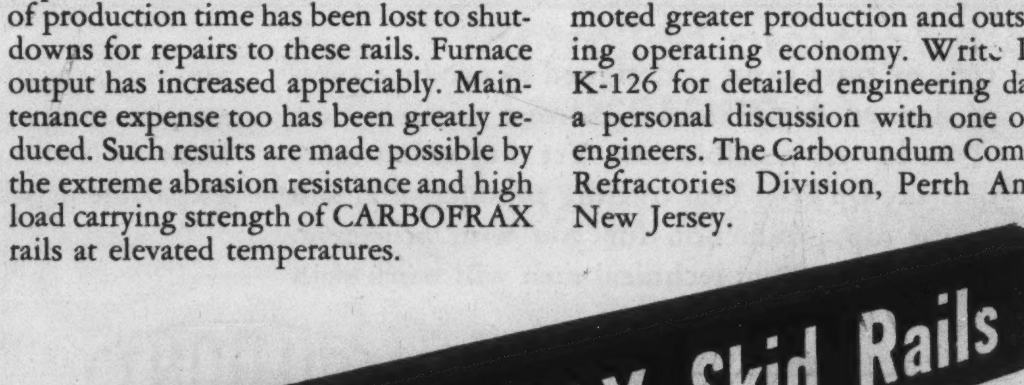
Output has increased tremendously since the installation of CARBOFRAX silicon carbide skid rails in this splice bar heating furnace used for reforming splice bars.

Costly shutdowns for repairs and replacement have been eliminated. Long uninterrupted production at lower cost has been attained under rugged conditions. As much as 35.4 tons of bars are pushed through this furnace in 7 hours. Operating temperature is approximately 2300°F.

Before using CARBOFRAX rails, this service proved far too tough for skids formed by 2½″ round of low carbon steel. On an average of every six weeks, they were completely shot. To remove and replace them meant a weekend shutdown. Two full working days were lost. In addition, because they warped badly in a short time, these steel skids had to be straightened several times during the short time between replacement. Still further production time was lost.

In excellent shape after two full years of operation, CARBOFRAX skids have required no attention. Not one minute of production time has been lost to shutdowns for repairs to these rails. Furnace output has increased appreciably. Maintenance expense too has been greatly reduced. Such results are made possible by the extreme abrasion resistance and high load carrying strength of CARBOFRAX rails at elevated temperatures.

Used in a variety of furnace installations, CARBOFRAX skid rails have promoted greater production and outstanding operating economy. Write Dept. K-126 for detailed engineering data or a personal discussion with one of our engineers. The Carborundum Company, Refractories Division, Perth Amboy, New Jersey.



BY CARBORUNDUM

TRADE MARK

"Carborundum" and "Carbofrax" are registered trademarks which indicat manufacture by The Carborundum Company

YOU GET METAL QUALITY DEVELOPED FULLY IN *Forgings*

Forged Oil Well Drilling Tool Part in which Grain Structure and Fibre-Like Flow Lines Inherent in the Steel Have Been Utilized Fully to Obtain the Maximum of Strength and Toughness Required to Endure Severe Service Conditions

PLUS THESE ADVANTAGES

High tensile and impact strength obtained through controlled concentration of grain structure and fibre-like flow lines.

A correctly proportioned combination of physical properties to meet a specific service condition.

Reduction of dead weight; maximum strength and toughness in lighter sectional thicknesses.

Reductions in cost at point of assembly due to less time required to machine and finish, and fewer rejects.

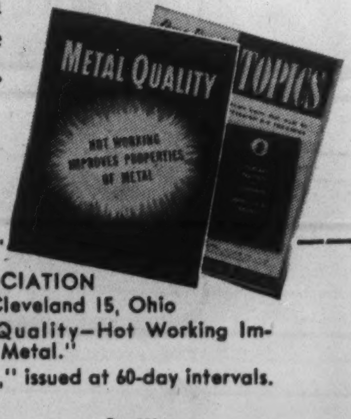
Rapid assembly of complex parts by welding, because forgings provide welding adaptability of widest range.

A reduction of accidents to men and machines, because forgings provide a greater margin of safety.

Controlled concentration of fibre-like flow line structure of metal at points of greatest shock and stress.

● Where designers once had to rely upon the mass and weight of metal to provide required strength in vital parts, today they can design primarily to achieve utility and efficiency. *Recent progress in the use of tougher steels, and in the employment of forging techniques,* by which many different shapes have been forged for the first time, *permit a greater degree of freedom in designing highly stressed parts.* While a part is still in the design stage, discuss service condition requirements with a forging engineer, who will be able to show you how to take full advantage of the fibre-like flow line structure of wrought metals to obtain the maximum strength and toughness and fatigue resistance. A recheck of every stressed part, whether of simple or complex design, against the many advantages that forgings offer may reveal the possibility of further strengthening a part or a product to give longer service life; to lessen weight; to reduce the cost of machining and finishing; to speed up assembly.

Consult a forging engineer connected with your source of supply about the wide range of combinations of quality and economic advantages that are available in forgings.

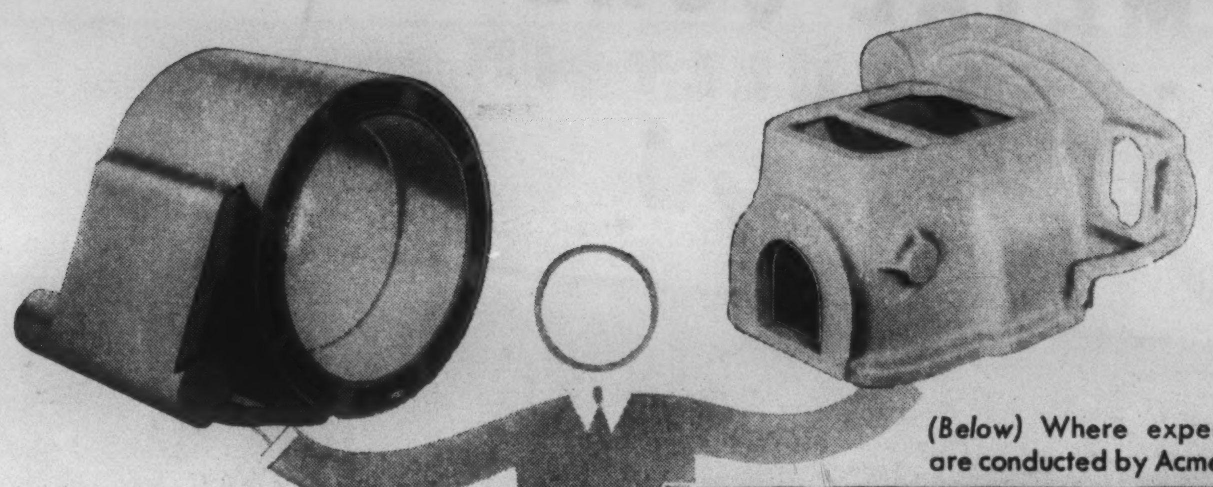

METAL QUALITY
HOT WORKING IMPROVES PROPERTIES OF METAL
TOPICS

ROP FORGING ASSOCIATION

5 HANNA BUILDING • CLEVELAND 15, OHIO

DROP FORGING ASSOCIATION
605 Hanna Building • Cleveland 15, Ohio
☐ **Booklet on "Metal Quality—Hot Working Improves Properties of Metal."**
☐ **"Drop Forging Topics," issued at 60-day intervals.**

Name .... **Position** ....
Company ....
Address .... **City** .... **State** ....



(*Below*) Where experiments with light metal alloys are conducted by Acme's Cooper Metallurgical Lab. Div.

Now you can obtain ALUMINUM CASTINGS with the STRENGTH OF MALLEABLE IRON

IF you doubt whether aluminum has the strength required for a particular part you need, put your problem up to Acme metallurgists. Acme Triple-A Almag 55 alloy, for instance, has the strength of malleable or cast iron, but only one-third the weight. Its tensile strength of over 50,000 psi—yield strength of over 28,000 psi—is speeding the change from heavy metals to light weight aluminum.

Don't continue to handicap your product with heavy-metal castings. Triple-A Almag 55 is but one of the new aluminum alloys developed by Acme's Cooper Metallurgical Laboratory Division. High-quality sand and permanent mold aluminum castings produced by Acme are helping many manufacturers reduce the weight and boost the salability of their product. Ask Acme what strong, light-metal castings may do for you.

GET THE FACTS. SEND FOR DESCRIPTIVE BULLETIN.

Write for new bulletin giving full technical details on Almag 55 aluminum alloy. Tell us also what your part or product must do—what strains it must meet, what impacts it must withstand, and get Acme recommendations and quotations on your castings requirements.

TRIPLE A

TRADE MARK

ACME ALUMINUM ALLOYS, INC.

DAYTON 3, OHIO

Aluminum, Brass, Bronze Castings · Patterns · Tools · Engineering

SALES OFFICES: Chicago Cleveland Detroit Philadelphia
Pittsburgh St. Louis Washington Minneapolis Flint Milwaukee Dallas

FOR GREATER STRENGTH *without more weight*

When used for locomotive side rods such as this, Republic Alloy Steels insure highest strength for the weight involved—and provide uniform hardenability that produces wear-resistant surfaces.

—no other material can equal

ALLOY STEELS

When power and speed of locomotives are stepped up—and operating parts such as side rods, pins and bolts must be made stronger without increase in size or weight—it's a job for Republic Alloy Steels.

Alloy steels are the strongest of metals. Their exceptionally high strength-to-weight ratio assures the most efficient combination of these two properties.

But there are other good reasons for your use of alloy steels. They can be hardened uniformly and accurately to the greatest extremes of any material—hence are highly resistant to abrasion. They insure against non-hardened or soft spots in wearing surfaces.

Alloy steels also provide super-toughness to resist sudden shock, strain or reversal of stress. They resist fatigue, high temperatures, sub-zero cold and corrosion. They are the most dependable and the hardest working steels that money can buy.

Republic's wide experience as the world leader in the production of alloy steels is yours—to help you increase efficiency of equipment, to keep it out of the repair shop longer and to cut costs. Write us.

REPUBLIC STEEL CORPORATION
Alloy Steel Division • Massillon, Ohio
GENERAL OFFICES • CLEVELAND 1, OHIO
Export Department: Chrysler Building, New York 17, N. Y.

Republic
ALLOY STEELS

Also Carbon and Stainless Steels—Sheets—Plates—Pipe—Upson Bolts, Nuts and Rivets—Electrunite Boiler Tubes

HERE'S REAL CONTACT EFFICIENCY!

SILVER-GRAPHITE
30% HARDER FOR LONGER LIFE . . .
GREATLY IMPROVED CONTACT DROP

SILVER-TUNGSTEN
STACKPOLE FW-41 FORMULA
HANDLES HIGH AMPERAGES

This new Stackpole material is 30% harder than conventional Silver-Graphite contact types. It greatly prolongs contact life under short circuit conditions, assures far better contact drop, and tremendously improves wearing qualities. It contains from 3½% to 10% graphite and can be made in practically any needed contact shape or size for a wide variety of circuit breaker, contactor and relay applications. On particularly difficult high-amperage applications the use of one of these contacts operating against an FW-41 silver-tungsten contact may provide truly outstanding efficiency.

Through the efficiency of this Stackpole silver-tungsten contact material, the interrupting capacity of a circuit breaker made by a leading manufacturer was increased from 10,000 to 15,000 amperes. On special test, it interrupted 21,000 amperes without apparent harm to the contacts! Not only that, but Stackpole's FW-41 contact formula paved the way to constructing this same circuit breaker to a size one-third smaller by volume and with half as many parts! Write for details.

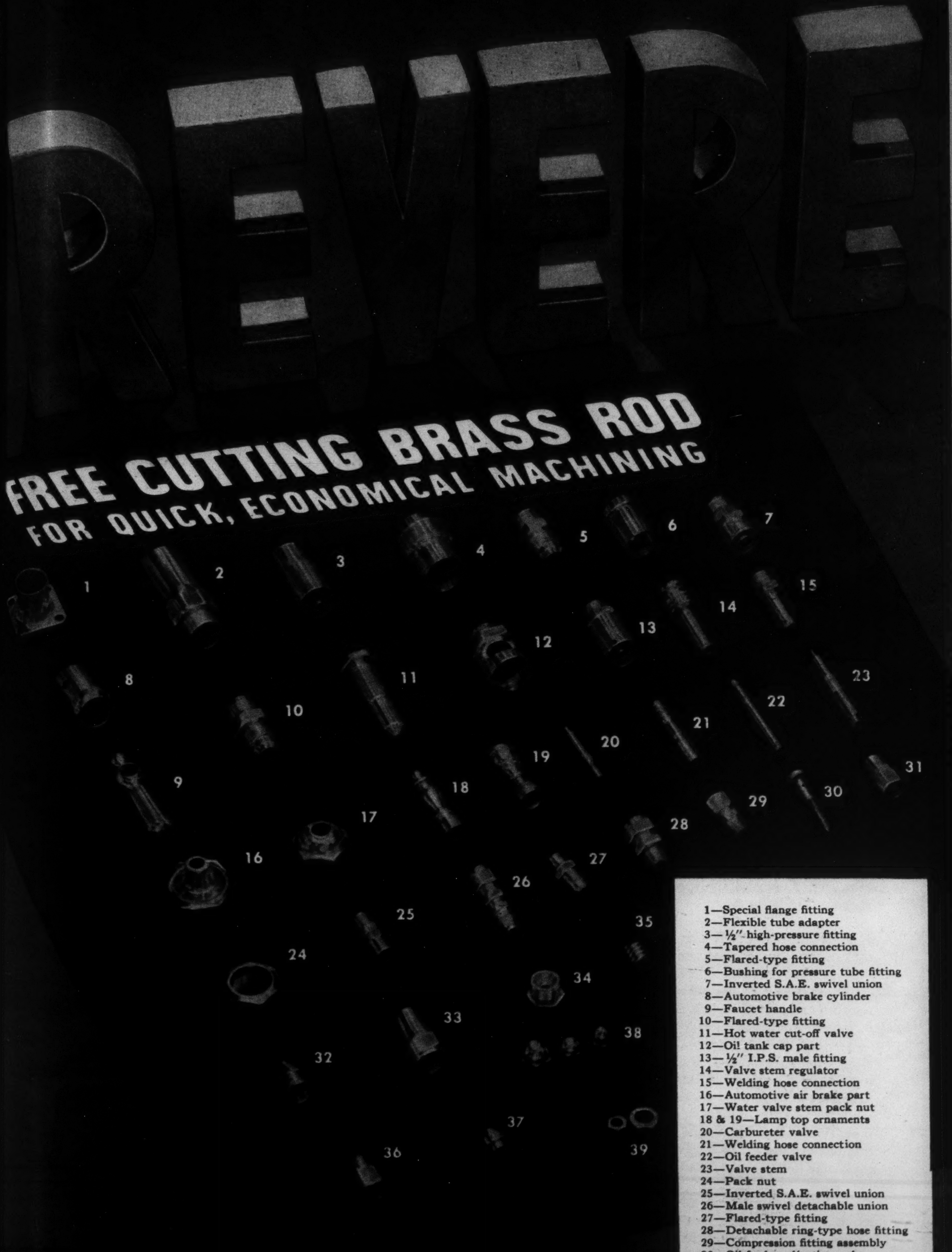
NOTE: Stackpole Contacts are sold only for original equipment purposes—not as replacements.

Write for Stackpole Contact Catalog and Data Book No. 12

STACKPOLE CARBON COMPANY, ST. MARYS, PA.

STACKPOLE

BRUSHES AND CONTACTS (All molded carbon, graphite, and metal composition types) • RARE METAL CONTACTS • SINTERED ALNICO II • WELDING CARBONS • MOLDED IRON CORES • PACKING, PISTON and SEAL RINGS • CHEMICAL CARBONS, etc.


REVERE
FREE CUTTING BRASS ROD
FOR QUICK, ECONOMICAL MACHINING
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1—Special flange fitting
2—Flexible tube adapter
3—½" high-pressure fitting
4—Tapered hose connection
5—Flared-type fitting
6—Bushing for pressure tube fitting
7—Inverted S.A.E. swivel union
8—Automotive brake cylinder
9—Faucet handle
10—Flared-type fitting
11—Hot water cut-off valve
12—Oil tank cap part
13—½" I.P.S. male fitting
14—Valve stem regulator
15—Welding hose connection
16—Automotive air brake part
17—Water valve stem pack nut
18 & 19—Lamp top ornaments
20—Carbureter valve
21—Welding hose connection
22—Oil feeder valve
23—Valve stem
24—Pack nut
25—Inverted S.A.E. swivel union
26—Male swivel detachable union
27—Flared-type fitting
28—Detachable ring-type hose fitting
29—Compression fitting assembly
30—Oil feeder adjusting valve
31—7/16" female compression union
32—Fuse part
33—S.A.E. long nut
34—Orifice spud
35—Worm gear
36—Threaded sleeve-type union
37—Toilet tank spud
38—Acorn nuts for finish trim
39—Hex nuts

Facts about REVERE FREE CUTTING BRASS ROD

Lead Content. Revere Free Cutting Brass Rod contains about 3% lead. This is not dissolved but is thoroughly distributed throughout the metal in the form of finely-divided particles. The lead reduces friction by causing the chips to break off short, so that they are in only momentary contact with the cutting edge of the tool. This lessens the amount of heat generated. Life of the tool is correspondingly extended, and long runs without regrinding are usual.

Machining Speeds. Surface speeds as high as 700 feet per minute are possible. Rough cuts as deep as 0.020″ can be taken. Such speeds and cuts materially reduce production time over other materials having less outstanding machining characteristics.

Finish. With proper tooling, parts made of Revere Free Cutting Brass Rod come from the machine with a brilliant, smooth, highly-polished appearance, due to the practically flawless surface. Any tolerance within the capability of the machine and operator may be easily obtained. Threads are sharp and clean down to their roots.

No Burrs. This metal may be cut- and roll-threaded, drilled and tapped, milled, broached, and sawed with no appreciable burrs.

Temper. In the majority of cases, Revere Free Cutting Brass Rod is supplied hard drawn. This hardness facilitates chip breakage, while the high strength resulting from drawing assures strong threads. However, if desired for special purposes, Revere can supply soft Free Cutting Brass Rod.

High Standards. Revere Free Cutting Brass Rod is drawn to close tolerances on dimensions and straightness, and is stress-relieved after drawing. The metallurgical and physical characteristics of the metal are under constant laboratory check. It is therefore especially suitable for automatic screw machines, which require stock having high uniformity in quality and dimensions.

Additional Advantages. The smooth surfaces produced by machining Revere Free Cutting Brass Rod are ideal for plating. The metal is easily soldered, can be welded if desired, and it is of course nonrusting and corrosion-resistant. Even at a slightly higher cost over other materials, this brass often is more economical for screw machine production, due to the speed with which the various operations may be conducted, and the value of the scrap.

Consult Revere. Because no single metal or alloy is suitable for all requirements, Revere offers many, each having some outstanding virtues and advantages. Selection of the most advantageous Revere Metal for a given process, part, or product may make a big improvement in such important items as cost of manufacture, durability, and even saleability. The Revere Technical Advisory Service will gladly cooperate with you in studying your requirements.

TYPICAL PROPERTIES

REVERE
FREE CUTTING BRASS ROD
Alloy No. 240

COMPOSITION

Copper	61.5%
Zinc	35.5
Lead	3.0

TENSILE STRENGTH

Hard* 65,000 pounds per square inch
Soft† 50,000

ELONGATION

% in 2 inches
Hard* 15
Soft† 50

DENSITY

0.307 lbs. per cubic inch

COEFFICIENT OF EXPANSION

.0000113 per °F @ 68° F

ELECTRICAL CONDUCTIVITY

28.6 (% I.A.C.S. @ 68° F)

THERMAL CONDUCTIVITY

73 Btu. per sq. ft. per ft.
per hr. per °F @ 68° F

*Hard, Rockwell B72 (app.)
†Soft, Rockwell F65 (app.)

Revere Metals include: Copper *and* Copper *Alloys:* Sheet and Plate, Roll and Strip, Rod and Bar, Tube and Pipe, Extruded Shapes, Forgings; *Aluminum Alloys:* Tube, Extruded Shapes, Forgings; *Magnesium Alloys:* Sheet and Plate, Rod and Bar, Tube, Extruded Shapes, Forgings; *Steel:* Electric Welded Steel Tube.

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, New York

Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; New Bedford, Mass.; Rome, N. Y.—Sales Offices in Principal Cities, Distributors Everywhere.

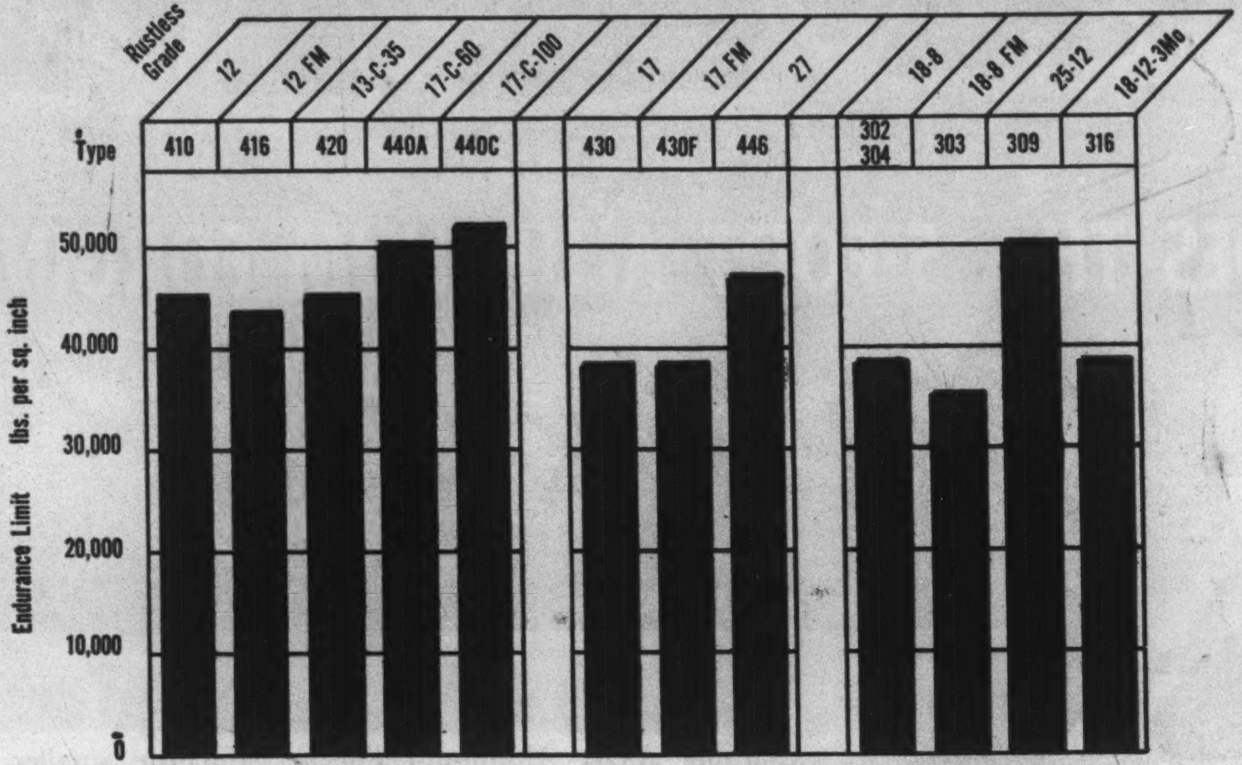
• • •

Listen to *Exploring the Unknown* on the Mutual Network every Sunday evening, 9 to 9:30 p.m., EST.

RUSTLESS DATA SHEET NO. 9

Corrosion Resistance
Plus Resistance to Fatigue

One of the Many Combinations of Properties Offered by Stainless Steels



METALS get tired. Under many repetitions of stresses metals become fatigued, and are not able to endure loads indicated as safe by the usual static tension and compression tests. When corrosive conditions are severe, this danger is exaggerated, causing a substantial drop in the safe loading stress. Stainless steels, however, show higher endurance limits or resistance to fatigue under many conditions, and will outperform other engineering materials under any number of repeated stress cycles.

Endurance limits have been established to indicate the safe loading stress which a material can withstand under an unlimited number of repeated stress cycles. Endurance limits are used in the design of moving machine parts such as pump shafting, aircraft controls, springs and instrument parts where loads are applied in repeated cycles—from maximum to zero, or from maximum tension to maximum compression. Endurance limits vary for different materials and for different conditions of that material. Endurance limits are closely related to tensile strength and usually approximate one-half the ultimate tensile strength. Therefore, any treatment which alters the tensile strength, also alters the endurance limit. Values of endurance limit indicated in the above chart represent stainless steels in the annealed condition and, therefore, are the minimum values to be expected. Hardening either by cold work or by heat treatment will raise the endurance limit to a considerable extent. Stainless steels not hardenable by heat treatment can be cold worked to obtain endurance limits approaching 100,000 pounds per square inch. Stainless grades hardenable by heat treatment go even higher. Types 420, 440A and 440C, when hardened and stress relieved, offer endurance limits well over 100,000 pounds per square inch—higher than many straight carbon steels, and much higher than any other standard engineering material.

There are many factors which affect fatigue and make it a complex subject. Scratches, machine marks, nicks, dents, and other surface irregularities form stress concentration points and promote the progressive failures which are characteristic of fatigue. Temperature has a pronounced effect on fatigue. Corrosion, in combination with fatigue, has extreme effects usually predictable only by studies of service performance. Fatigue is a subject requiring special attention. When you want to use stainless steel to resist corrosion fatigue, consult our specialists.

Automatic bottling equipment must withstand a severe combination of service conditions, and must be made of material of high fatigue strength—

For a complete report on why one prominent manufacturer uses stainless steels almost exclusively for this purpose, and how the hundreds of different parts are machined to rigid quality standards at high production rates—request a copy of Rustless' latest 3-page case history "Machining Stainless Steels by Preference."

Machining Stainless Steels by Preference

SALES OFFICES:
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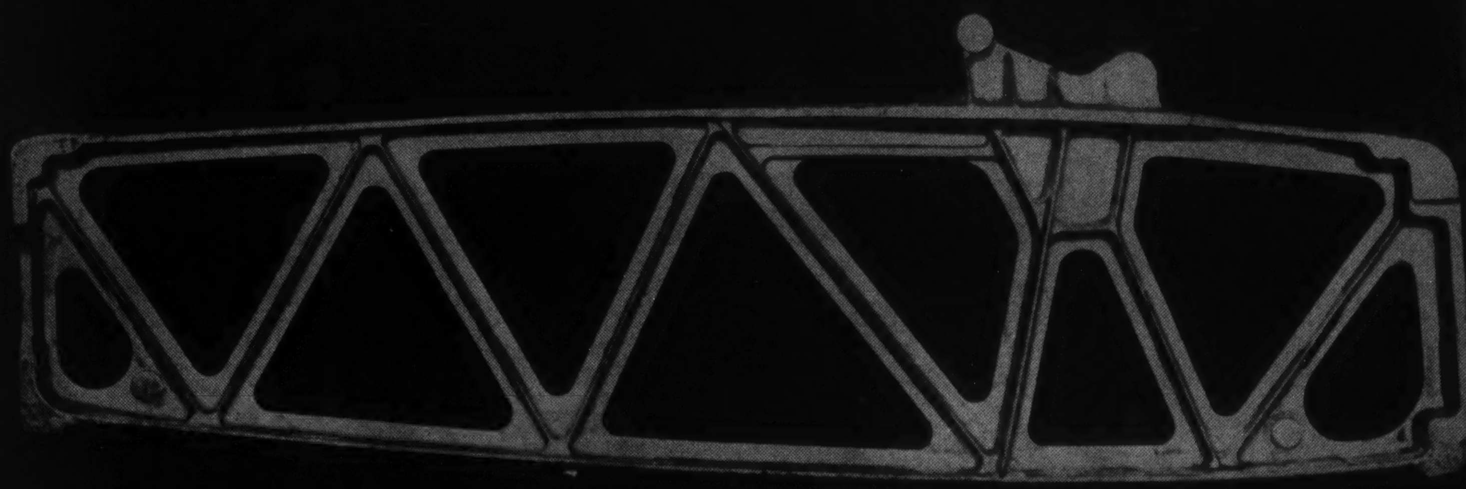
Rustless

DIVISION OF ARMCO

RUSTLESS IRON AND STEEL DIVISION
THE AMERICAN ROLLING MILL COMPANY
Baltimore 13, Maryland
STAINLESS STEEL SPECIALISTS



DOES THIS 5-FOOT ALUMINUM FORGING

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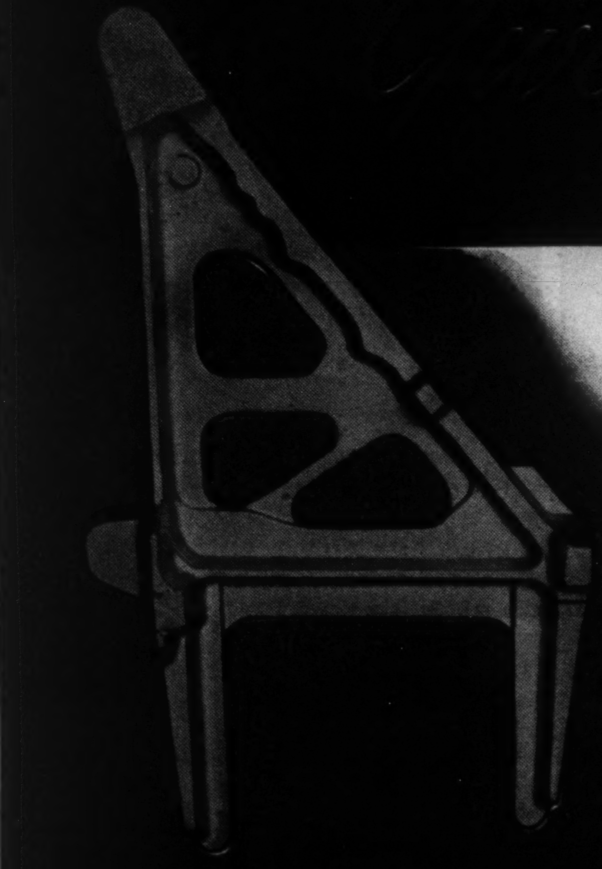
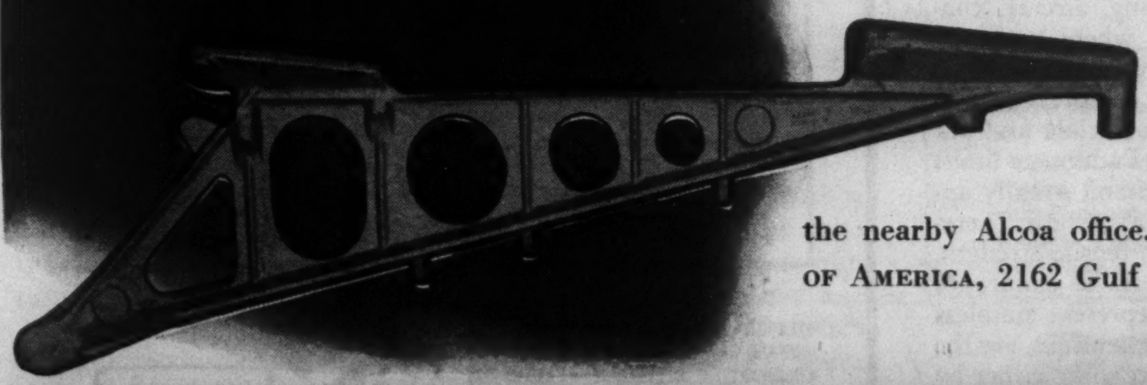




This big Alcoa Aluminum Forging and the smaller pair are airplane structural members. You know they're dependable, therefore, yet they save weight where lightness is essential. Consider them against your needs—

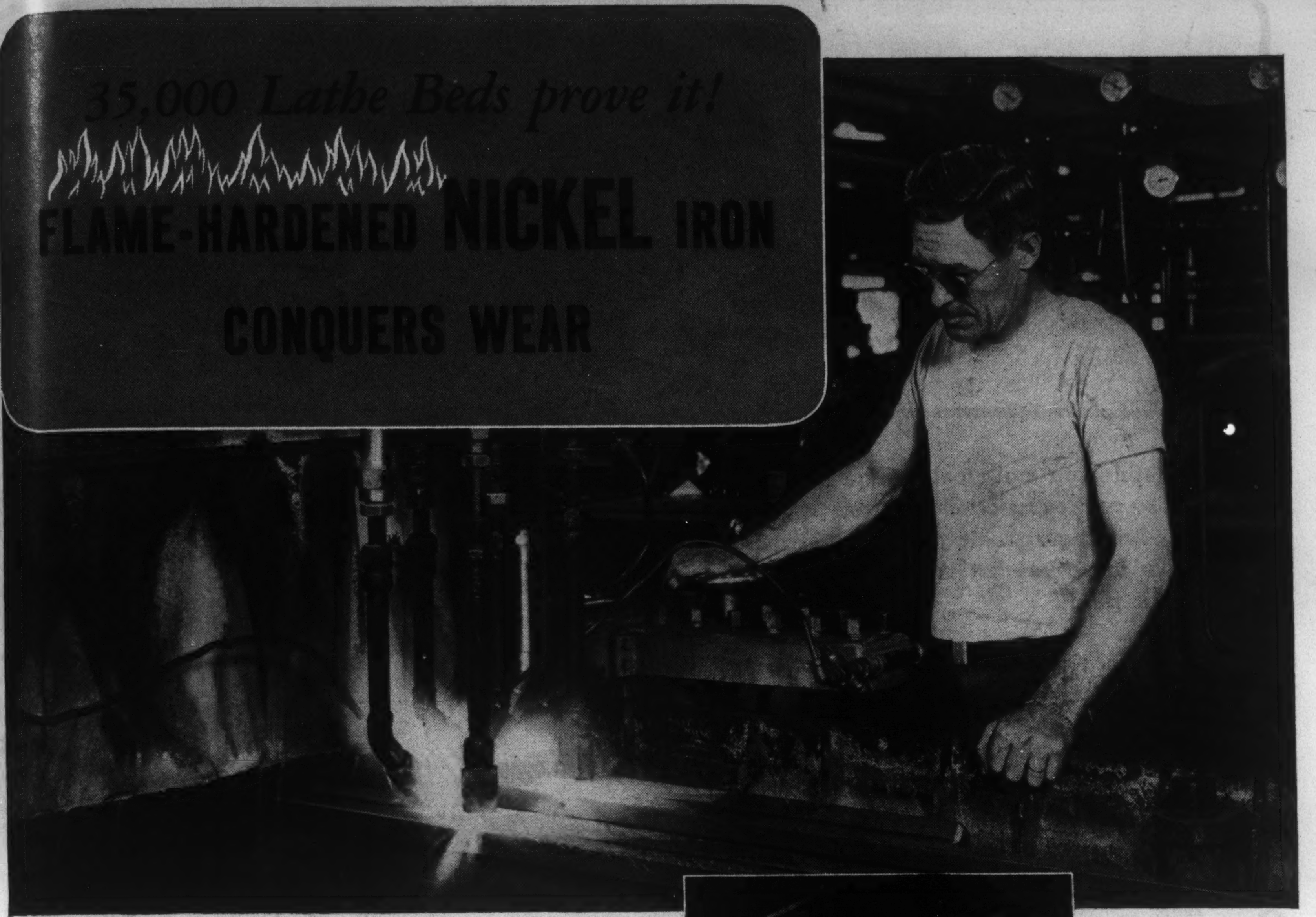
They're massive parts; capable, because of their grain structure, the choice of alloy, and their design, of taking plenty of punishment. Their complex shape shows that you need not feel restricted in designing forgings of Alcoa Aluminum.

Used in parts that move or products that must be moved, Alcoa Aluminum Forgings enable you to reduce dead weight without sacrificing strength or safety. For help in including them in your products, call the nearby Alcoa office. Or write ALUMINUM COMPANY OF AMERICA, 2162 Gulf Building, Pittsburgh 19, Penna.

ALCOA ALUMINUM

ALCOA ALUMINUM

IN EVERY COMMERCIAL FORM



35,000 Lathe Beds prove it!

FLAME-HARDENED NICKEL IRON CONQUERS WEAR

During the past 5 years The Monarch Machine Tool Company has built more than 35,000 lathes.

So, they know a lot about lathes . . . and lathe *beds*, too.

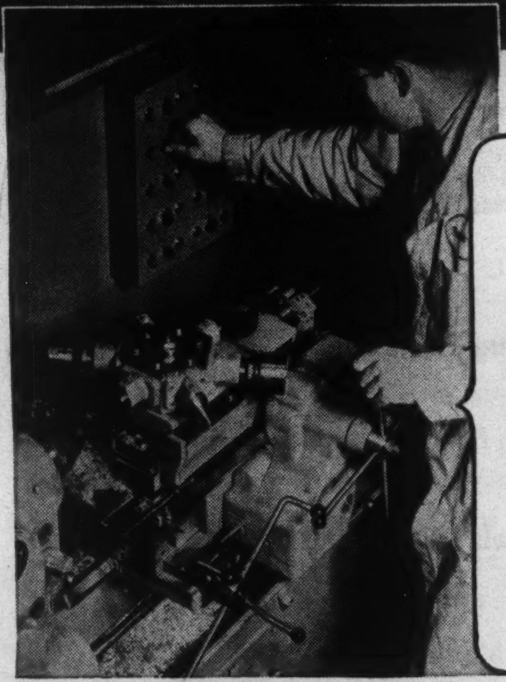
They know how to build beds that resist abrasion, scoring, wear . . . and maintain high accuracy to keep users' production costs low.

That's why Monarch specifies Nickel alloyed iron for all beds.

Experience shows good reason for this. For example, when their Nickel iron lathe beds, 8½ feet long, are flame-hardened to a depth of ⅛″ to ¼″, the warpage is only about 0.01″. During finishing, this is ground off and final tolerance is only 0.0005″.

The Nickel in the cast iron lowers the critical transformation range . . . thus, gives greater depth of hardness than in plain iron and minimizes distortion. Moreover, there is gradual blending of the flame-hardened layer into the softer pearlitic interior, whereas in unalloyed iron the transition zone is apt to be completely graphitized and hence extremely weak.

Consult us on the use of Nickel to meet your casting requirements. Send us details of your problems today.



In this SPEED-MATIC *hand screw machine, Monarch uses gears, shafts and pinions of Type 8749 Nickel alloy steel, along with flame-hardened Nickel cast iron beds.*

EMBLEM OF SERVICE

INCO Nickel

TRADE MARK

Over the years, International Nickel has accumulated a fund of useful information on the selection, fabrication, treatment and performance of alloys containing Nickel. This information and data are yours for the asking. Write for "List A" of available publications.

THE INTERNATIONAL NICKEL COMPANY, INC. **67 WALL STREET**
NEW YORK 5, N. Y.

BETHLEHEM

Tool Steel Reference List

Bethlehem tool steels range from the straight-carbon types to the highly-alloyed, special-purpose grades so often required in modern practice.

Broadly speaking, the standard Bethlehem tool steels come under seven main headings. The following list is a general guide, and it includes the steels for almost every job in your plant:

	CLASSIFICATION	TYPE ANALYSIS	TRADE NAMES
1.	**General-Purpose Tool and Die Steels** *(water-quenching)*	C or C-V 0.70 to 1.40 carbon range	X; Best; XCL; Superior; XX
2.	**Safe-Hardening Tool and Die Steels** *(oil-quenching)*	Mn-Cr-W-V	BTR
		Ni-Cr-Mo	Bethalloy
3.	**Air-Hardening Tool and Die Steels** *(air-quenching)*	Mn-Cr-Mo	AH; AH-5
4.	**High-Production Tool and Die Steels**	High C, High Cr	Lehigh L; Lehigh H; Lehigh S
5.	**Shock-Resisting Steels**	Si-Mn	No. 71 Alloy; Omega
		W	No. 67 Chisel
		Cr-V	Tough (H and M tempers)
6.	**Hot-Work Steels**	Cr-Mo	Cr-Mo-W; Cr-Mo-V
		W	No. 57 Hot Work; No. 57 Special Hot Work
7.	**High-Speed Steels**	W	Bethlehem Special High Speed; Comokut; Red Tiger (Improved)
		W-Mo	66 High Speed; Moco; HM

Remember, our specialists are always ready to talk applications with you. Call us when tool-steel problems get tough—or better still, let us work with you from the start.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by
Bethlehem Pacific Coast Steel Corporation

Bethlehem tool steels for every purpose

BETHLEHEM
STEEL

Let's look for BUTTONHOOKS in your production picture

Even in the most modern and progressive plants, there may be certain operations that are holdovers from another manufacturing generation. They're there by tradition, like a buttonhook on the bureau.

Take the production of parts by conventional methods. In many cases, these same parts could be produced faster, cheaper and better by using ArmaSteel in place of forgings or bar stock. This versatile metal, with its exceptional heat-treating properties, offers a wide range of physical characteristics to meet varied requirements. It greatly reduces machining requirements through the inherent economy of castings, and cuts machining time still further by providing up to 30% better machinability.

We'd like to show you some case histories of how ArmaSteel has saved money and stepped up production of parts for other manufacturers . . . and discuss what ArmaSteel can do for you. In these days of high production costs, we think you'll be particularly interested.

SAGINAW MALLEABLE IRON DIVISION OF GENERAL MOTORS, SAGINAW, MICHIGAN

CAST FOR A LEADING ROLE IN INDUSTRY

ArmaSteel*

*Reg. U.S. Pat. Off.

It takes all seven..

to permit you to select the Insulating Fire Brick with the correct *balance* of thermal and physical properties for each service in your plant.

PROPERTIES	INSULATING BRICK			INSULATING FIRE BRICK AND FIREBLOK			
	Sil-O-Cel Natural	Sil-O-Cel C-22	Sil-O-Cel Super	JM-1620	JM-20	JM-23	JM-26
Density—lb. per cu. ft.	30	38	40	29	35	42	48
Transverse Strength—lb. per sq. in.	140	115	90	60	80	120	125
Cold Crushing Strength—lb. per sq. in.	400	700	300	70	115	170	190
Linear Shrinkage—Percent	1.4 @ 1600F	0.8 @ 2000F	2.0 @ 2500F	0.0 @ 2000F	0.0 @ 2000F	0.3 @ 2300F	1.0 @ 2600F
Reversible Thermal Expansion—Percent	0.1 @ 1600F	0.7 @ 2000F	1.3 @ 2000F	0.5—0.6 @ 2000F	0.5—0.6 @ 2000F	0.5—0.6 @ 2000F	0.5—0.6 @ 2000F
Conductivity at Mean Temperature	‖ ⊥						
500F	1.01 .67	1.67	1.70	.77	.97	1.51	1.92
1000F	1.13 .79	1.88	1.95	1.02	1.22	1.91	2.22
1500F	1.24 .90	2.08	2.19	1.27	1.47	2.31	2.52
2000F	— —	—	2.45	—	1.72	2.70	2.82
Recommended Service							
Back Up	1600F	2000F	2500F	2000F	2000F	2300F	2600F
Exposed	—	—	—	1600F	2000F	2300F	2600F
Recommended Mortar for Setting Brick	Sil-O-Cel Mortar	Sil-O-Cel Mortar	Sil-O-Cel Super Brick Mortar	J-M No. 1626 Cement	J-M No. 1626 Cement	J-M No. 1626 Cement	J-M No. 1626 Cement

Note: 1. Above tests are in accordance with ASTM tentative standards.
2. Conductivity is expressed in Btu in. per hr per sq ft per deg F at the designated mean temperatures.
3. ‖ —with heat flow parallel to brick strata.
⊥ —with heat flow perpendicular to brick strata.

No one brick can perform properly under all steel mill service conditions. That's why Johns-Manville makes seven types of Insulating Brick and Insulating Fire Brick. Each is designed for a specific job . . . and *engineered* to do its job with maximum efficiency.

The three J-M Insulating Brick provide great structural strength; the four J-M Insulating Fire Brick combine strength with exceptional resistance to spalling. All offer the advantages of light weight and low conductivity. They are recommended as back-up insulation or insulating fire brick for all industrial requirements.

For complete details, write Johns-Manville, Box 290, New York 16, N.Y.

JOHNS-MANVILLE *First in* **INSULATION**

This

BLUE CHIP

High Speed Steel Die

Lives Up to its Name!

- **produces 75,000 pieces per grind**
- **has a life of 8,000,000 pieces**
- **furnishes blanks free from burrs**

The remarkable performance records being made by this Blue Chip Blanking Die for motor laminations are typical of Firth-Sterling quality and precision. What is your die problem?

Call **Firth-Sterling**

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CYANIDING IS ECONOMICA
The HOMOCARB Way

Dense loads of these tiny oval eyes get an 0.012-inch case in one hour of cyaniding by the Homocarb Method, in the plant of H. I. Judd Co., Wallingford, Conn., manufacturers of textile machine parts and other mill wire goods.

➡

Lowering load of refrigerator hooks into Homocarb for gas-cyaniding.

Cyanided steel parts can have not only file-hardness but uniform hardness and reduced distortion when they are gas-cyanided in the Homocarb way. Several reasons explain these results:

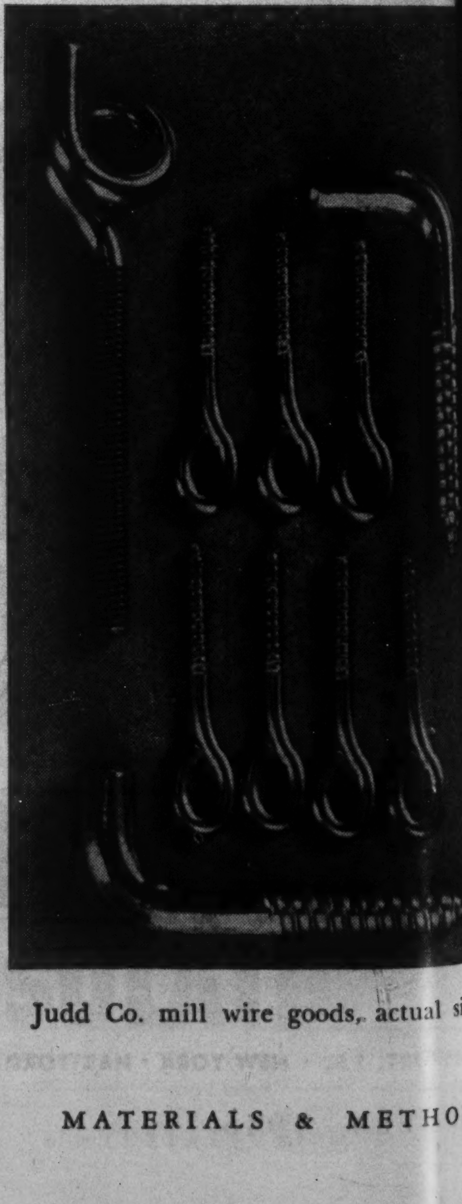
1. Gas cyaniding deposits no coating on parts, and work can therefore be quenched in either water or oil, acquiring file-hard case in either.

2. Fresh cyaniding gas is automatically fed to the Furnace in a continuous stream, and spent gas exhausts promptly from the Furnace. Cyaniding medium is thus always held at full strength.

3. This uniform medium acts on the work with great uniformity, because the entire internal design of the Furnace is planned for that one purpose. Gas follows the short, efficient Homo path from the fan, past the heaters and into work. Snug fitting prevents by-passing and ample power insures uniform penetration of dense loads. Results are constant and predictable.

4. Automatic control is by our newest, most economical method—Micromax D.A.T. It gives proportioning control by on-and-off contacts; normal voltage changes don't affect regulation. Rejects often vanish; are always insignificant.

If you have a specific problem, in cyaniding or carburizing, we suggest you write for Homocarb Catalog T-623, or a call from an L&N Field Engineer, as you prefer.



Judd Co. mill wire goods, actual size

LEEDS & NORTHRUP COMPANY, 4925 STENTON AVE., PHILA., PA.

LEEDS & NORTHRUP

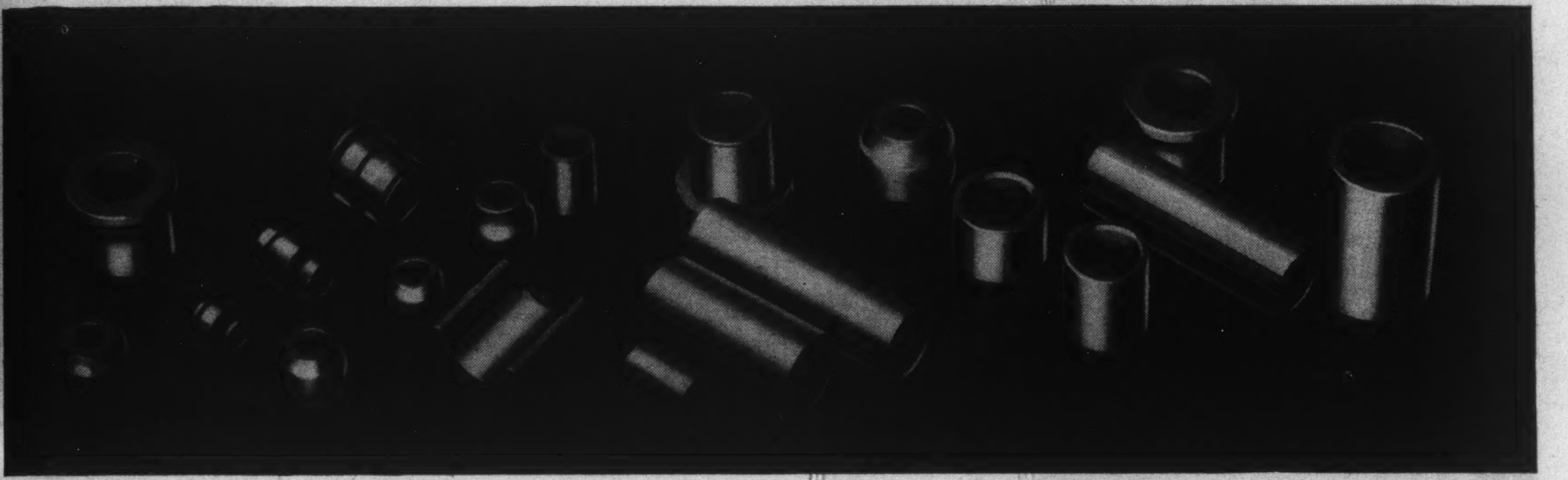
MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

Jrl. Ad T-623 (23)

The RIGHT *amount of* OIL *in the* RIGHT *place at the* RIGHT *time*

Oil is the lifeblood of a bearing. Proper lubrication forms a protecting film between the shaft and the bearing . . . prevents metal-to-metal contact . . . cuts friction to a minimum . . . prolongs the life of the entire motive unit.

One reason why Johnson LEDALOYL Bearings operate so quiet . . . so smooth . . . and for so long a time is the self-lubricating feature. Myriads of tiny, evenly spaced pores . . . as many as 13,000 to the square inch . . . serve as miniature oil wells. When the bearing is in use these pores meter the oil to the bearing area. When the bearing is at rest the oil is reabsorbed. Thus you always have the *right* amount of oil in the *right* place, at the *right* time.



in Powder Metallurgy *it's*

JOHNSON *Ledaloyl*
SELF LUBRICATING
REG. U. S. PAT. OFF.
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BRONZE

The dependable self-lubricating action of Johnson LEDALOYL provides many worthwhile savings to the designer. Expensive lubrication aids are eliminated and, in many cases, the bearings can be sealed in place. They are ideal for all types of household equipment. Write for complete, technical information.

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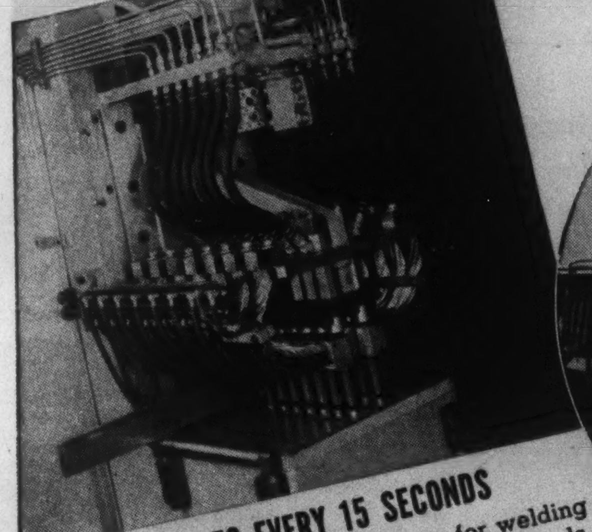
769 SOUTH MILL ST. NEW CASTLE, PA.

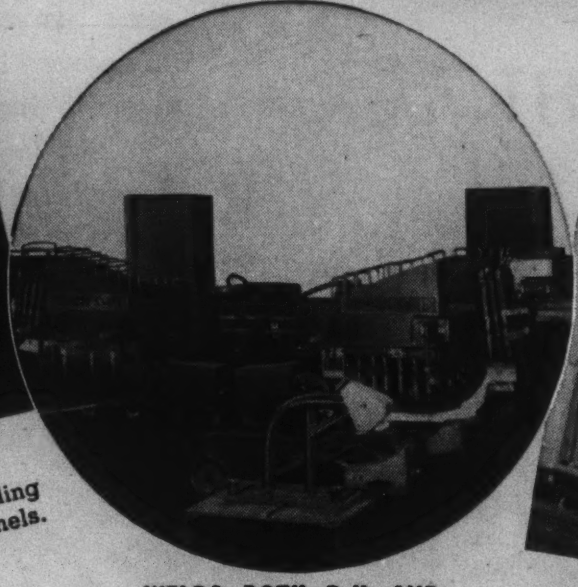
JOHNSON BRONZE
SLEEVE BEARING HEADQUARTERS
BRANCHES IN 18 INDUSTRIAL CENTERS

Some reasons why IT PAYS TO DESIGN for RESISTANCE WELDING



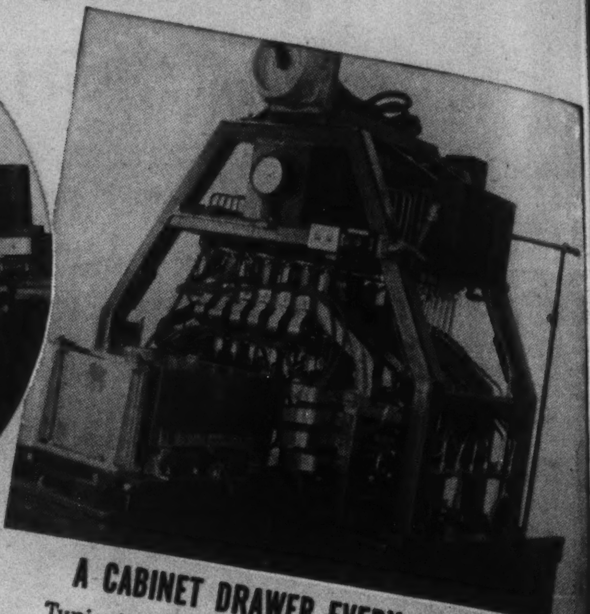
14 SPOTS EVERY 15 SECONDS

Typical PROGRESSIVE Hydromatic for welding 11 gage stake pockets to truck body panels.



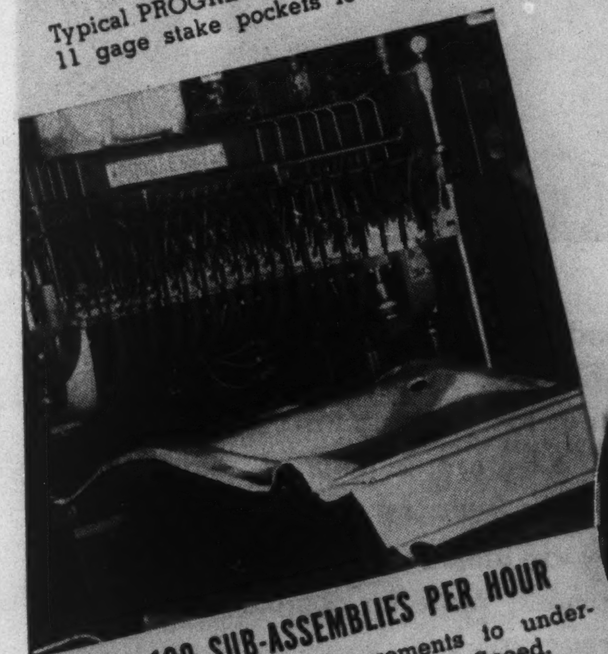
WELDS BOTH R.H. AND L.H. FENDERS AT 175/hr.

PROGRESSIVE Duplex Ultra-Speed welds 18 points on each while the other side is being loaded.



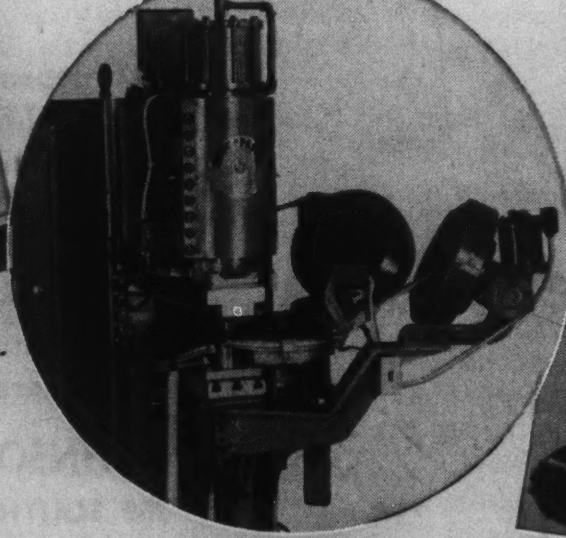
A CABINET DRAWER EVERY 15 SECONDS

Typical PROGRESSIVE Hydromatic assembles drawers for stoves, cabinets, refrigerators, etc., with up to 48 spot welds.



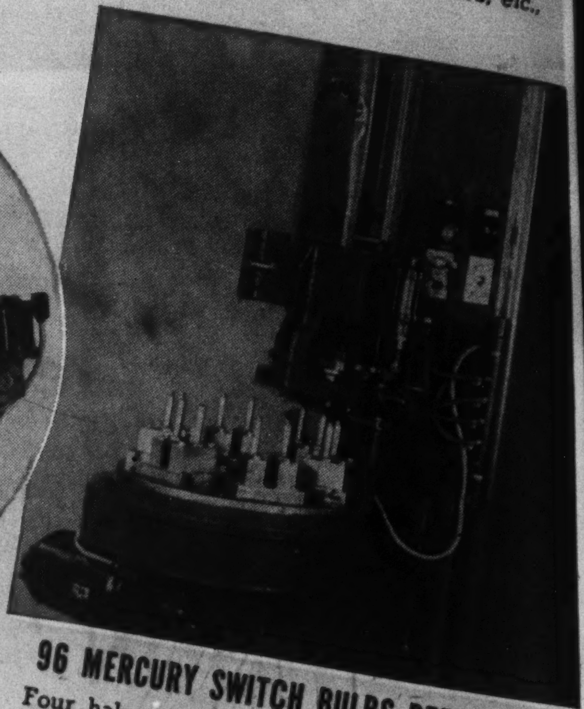
OVER 100 SUB-ASSEMBLIES PER HOUR

Welding cross sill reinforcements to underbodies with a PROGRESSIVE Ultra-Speed.



10,000 BEARING CUPS PER DAY

Automatic loading, feeding, indexing and ejection are built into this PROGRESSIVE Projection Welder.



96 MERCURY SWITCH BULBS PER MINUTE

Four halves of two mercury switch bulbs are projection welded simultaneously on this six-stage dial indexing PROGRESSIVE Press Welder.

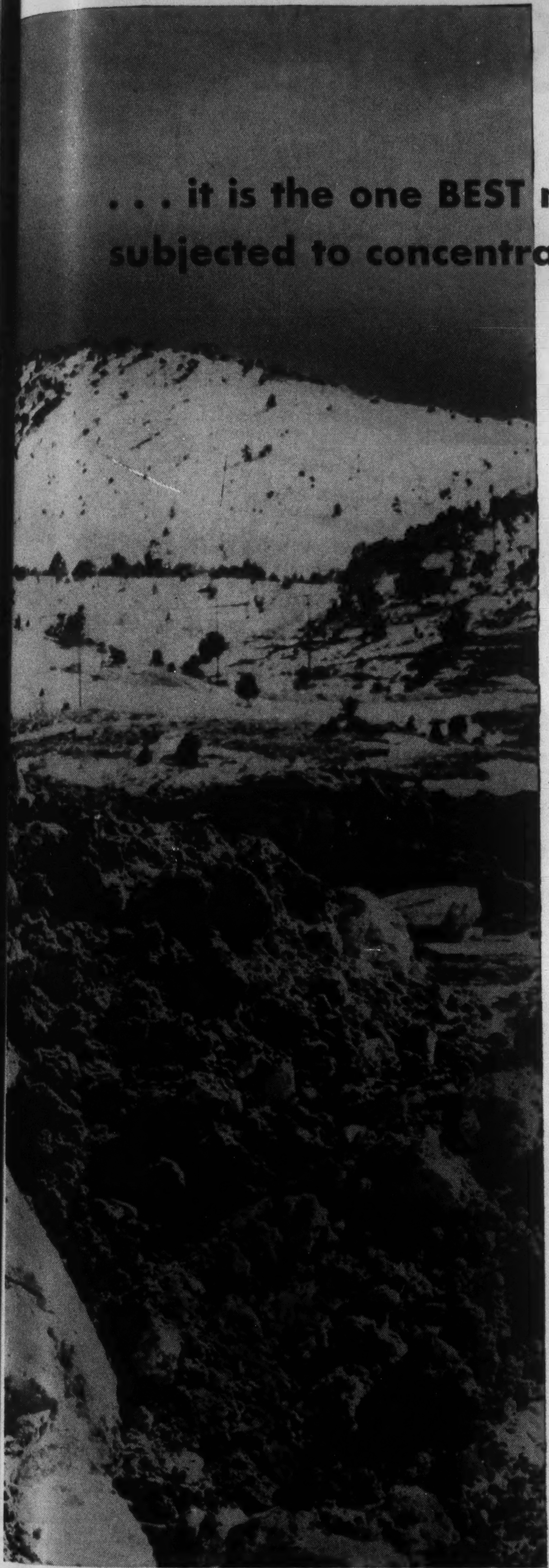
IT PAYS TO WELD

For news of the latest developments in resistance welding equipment and methods, influencing product design, ask to be put on the mailing list for the Progressive "WELDING PICTORIAL".

MEMBER RWMA

PROGRESSIVE *Welder Co.* 3050 E. OUTER DRIVE • DETROIT 12

RESISTANCE WELDING EQUIPMENT



. . . it is the one BEST metal to use where parts are subjected to concentrated stress, wear, and shock

BECAUSE steel is tough . . . *tougher than any other metal* . . . it is the basic raw material for countless products that must be built to take abuse.

Yet steel, to be tough enough for the *specific use*, has to be designed that way. And therein lies its remarkable versatility.

Steel can be designed to combine toughness with a wide variety of other metallurgical characteristics that will best adapt it to the many different jobs it has to do. It can be made tough and elastic . . . tough and ductile . . . tough and hard. It can be made almost anything it has to be.

That's why, when you are ready to select steel for your product, it will pay you to check with our metallurgical experts. Tell us what you want the steel to do and we'll tell you which steel of the thousands available has just the right combination of features to do the best job at the lowest cost to you and your customers.

CARNEGIE-ILLINOIS STEEL CORPORATION
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UNITED STATES STEEL

Linde SYNTHETIC SAPPHIRE

has Proved its Worth

In Such Uses As . . .

BEARINGS which ensure accuracy of precision instruments.

THREAD GUIDES which resist the abrasive action of synthetic and natural fibers.

PRECISION GAGES which maintain dimensional fidelity and outwear steel gages over 100 times.

OIL BURNER NOZZLES which retain constant orifice size and resist the deposition of carbon on their highly polished surfaces.

BURNISHING WHEELS which produce high polish on non-ferrous metals.

PHONOGRAPH NEEDLES which reproduce faithfully over long periods of time without dulling their fine highly polished points.

WIRE GUIDE DIES which maintain size and shape of opening against constant friction.

GAGE POINTS which remain smooth and dirt-free for accurate gagings.

LINDE Synthetic Sapphire Has These Features . . .

1. Hardness = 9 Mohs' scale
2. Tensile strength = 65,000 psi
3. Resistance to commercial chemicals
4. Dielectric constant = 7.5-10
5. Melting point = 2,030 deg. C.
6. Thermal conductivity = 0.007 deg. C/cm^2/cm
7. Can be bonded to metals
8. Economical flame-fabrication in rod form

Write . . . Tell us your problems of wear in industrial equipment — our engineering staff will advise you whether or not synthetic sapphire can help in the solution.

Half-boules, weighing up to 150 carats
Rods 0.065-in. to 0.125-in. diameter

Choose From These Two Forms

The word "Linde" is a trade-mark of The Linde Air Products Company

THE LINDE AIR PRODUCTS COMPANY
Unit of Union Carbide and Carbon Corporation
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30 East 42nd Street, New York 17, N. Y.

Roller hearths of INCONEL seamless tubing give long, economical service in SURFACE COMBUSTION furnaces

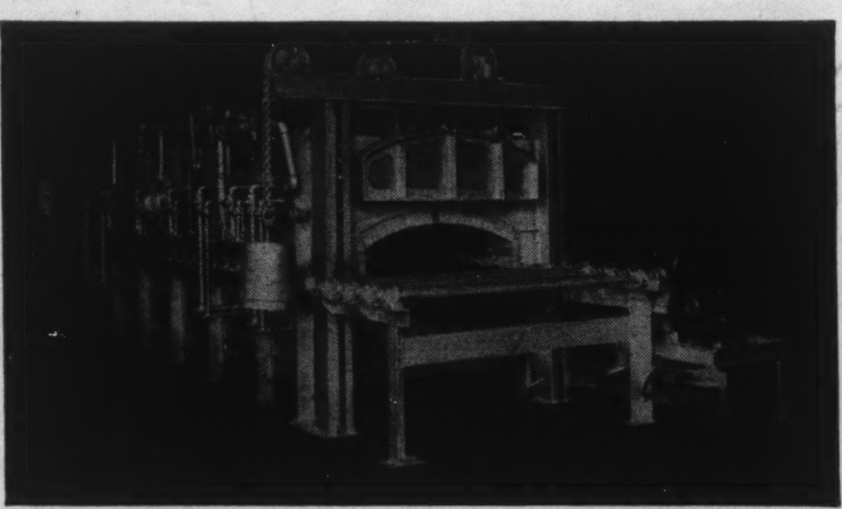
In the Surface Combustion furnace illustrated, the rollers are made of 2¼″ O.D. seamless Inconel tubing with walls .120″ and .134″ thick. The furnace handles 275 8-lb. shovel blanks per hour, heated from cold to 1650° F.

The user of the equipment reports: *"substitutes (for Inconel) have proved unsatisfactory, requiring considerable maintenance with consequent lost production time."*

Inconel seamless tubing, available in a wide range of sizes, is giving excellent service in many high temperature jobs where strength and resistance to oxidation are required ... it gives long life, cuts down-time, helps maintain a steady, trouble-free production.

For further information, write for the new bulletin, "INCO Nickel Alloys for Long Life in Heat Treating Equipment." Address:

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street **New York 5, N. Y.**



SURFACE COMBUSTION FURNACE, *3′ 9″ wide x 18′ 6″ long, with rollers on 9½″ centers. The rollers are made of strong, heat-and oxidation-resistant Inconel seamless tubing (2¼″ O.D. x .120″ wall x 60″ and 2¼″ O.D. x .134″ wall x 60″). They carry 2200 lbs. of shovel blanks ... a rated conveyor load of 2.5 lbs. per sq. ft. at 1500°—1650° F.*

NICKEL INCO ALLOYS
TRADE MARK

MONEL* • "K" MONEL* • "S" MONEL* • "R" MONEL* • "KR" MONEL* • INCONEL* • NICKEL • "L" NICKEL* • "Z" NICKEL*

*Reg. U. S. Pat. Off.

What's Right for Round Jobs?

WHICH is the most efficient modern technique for forging "round jobs"? It can be either, mechanical press or upsetter, depending on your particular requirements.

With a wide range of capacities in mechanical presses *and* upsetters, TUBE TURNS is a good mass-production source for these "round jobs."

Both techniques at TUBE TURNS give you forgings—properly held to specified tolerances—with metal that has gone all the way out to the end of the dies, perfect flow lines and *forged* tensile strength throughout.

TUBE TURNS' mechanical presses and upsetters are closely coordinated under one roof with complete die designing, die making, laboratory, and rough machining facilities. You get a highly desirable continuity of effort from start to finish of your job.

Send your prints for the recommendations of TUBE TURNS engineering staff. TUBE TURNS (Inc.), Louisville 1, Kentucky.

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Advertisement
DECEMBER, 1946

COPPER ALLOY BULLETIN

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared Each Month by Bridgeport Brass Co. "Bridgeport" *Headquarters for BRASS, BRONZE and COPPER*

Wide Range of Copper-Base Alloys Developed for Electrical Requirements

Industry is moving forward, and the use of electricity continues to grow for electronic applications; melting and heat treatment of metals; counting and sorting devices; for automatic controls and for many other applications too numerous to mention. In urban and rural homes and on the farms electricity is used increasingly for food preservation, to eliminate unnecessary drudgery and to get work done more quickly and efficiently.

Certainly no electrical equipment is any better than the material from which its vital parts are made, and with the ever-increasing use of electrical appliances come important responsibilities for designers and engineers. Which material is best suited for the particular job at hand from the standpoint of dependability and long service life? What alloys are available and what improvements have been made in existing alloys?

Because of their wide range of desirable physical properties, workability and corrosion resistance, copper and copper-base alloys have for many years found ever wider acceptance in the manufacture of electrical apparatus. With the use of modern, powerful mill equipment, closer casting control and improved annealing furnaces, a group of copper-base alloys with exceptionally fine physical properties has been developed. Greater dependability, higher strength, more resistance to corrosion, wear and fatigue are adding service life for electrical and mechanical devices. Present-day mass production calls for great uniformity of metal as to composition, gauge, and temper for the successful operation of automatic machines.

Phosphor Bronze For Springs (Grade A No. 36, Grade C No. 35)—Modern phosphor bronzes are characterized by exceptional fatigue resistance and great toughness. They are among the best available alloys from the standpoint of corrosion resistance. Phosphor bronzes are used successfully for the manufacture of switch and relay springs which must withstand millions of flexing cycles without failure; for contacts and fingers, and in many other electrical applications. They are also used for bellows, diaphragms and springs in pumps and automatic controls.

The spring properties of phosphor bronze strip are developed by cold-rolling the metal, generally from 6 to 10 B. & S. numbers hard (50% to 68% reduction). Because of the amount of rolling necessary to produce spring temper, care must be exercised in the designing of parts, particularly with reference to the direction of bending. When bent 90 degrees the hard rolled metal will have more tendency to crack parallel to the grain than across the grain. This must be taken into account when severe bends are involved. For certain conditions it may be advisable to stamp the article at 45 degrees to the direction of rolling. Care should also be taken to avoid sharp corners on the tools and, wherever possible, to use as large a radius as permissible.

The most commonly used phosphor bronzes for spring applications are Grade A (approximately 95% copper, 5% tin) and Grade C (approximately 92% copper, 8% tin). Both alloys have similar properties, but Grade C is used for more severe conditions.

Aluminum Bronze (No. 712)*—In line with a consistent program of research, Bridgeport's Laboratory developed a new spring material which contains no tin and which is composed of copper, aluminum and silicon. This alloy was released in the form of strip and has been successfully used for spring contacts in electrical equipment, diaphragms, bellows, spiders for self-centering bearings and many other parts. Its fatigue resistance, dependable spring properties and toughness indicate a wide range of applications in switches, relays, capacitors, jack plugs, temperature controls, and other parts. Its electrical conductivity is comparable to Grade C phosphor bronze.

Duronze II (No. 1232)—Approximately 97% copper, 3% silicon. In applications which require a corrosion-resistant spring material, less expensive than phosphor bronze and where low conductivity is not detrimental, Duronze II can be used. In some applications the greater strength of silicon bronze is advantageous, and its forming properties are at least equal to phosphor bronze. The yield strength of Duronze II is lower than that of phosphor bronze, and limits its use to applications where the required bending movement is not too great.

Bronze (No. 840)—Copper 98.6%, tin 1.4%. This alloy has 40% minimum conductivity and is used where spring properties are not as important as electrical conductivity and corrosion resistance.

Nickel Silver (No. 555)—Approximately 55% copper, 18% nickel, remainder zinc. This alloy is silver-white in color and possesses good corrosion resistance, fairly good spring properties and can be used for applications where high electrical resistance is desired. It is specified for telephone switchboard parts, as well as various items in radios and other electrical apparatus.

Cadmium Copper (No. 985)—There are a great many electrical applications which require a material with high electrical conductivity, better resistance to the effects of arcing and with more stiffness and wear resistance than copper. Bridgeport's Cadmium Copper amply fulfills these requirements, and in order to attain the highest possible electrical conductivity (85% minimum) consistent with strength and hardness, it is alloyed under carefully controlled conditions, processed by modern equipment and, of course, subjected to constant laboratory control.

Oxygen-Free Copper (No. 104)—This metal is used for applications requiring the most pure copper and the highest possible electrical conductivity. For example, ex-

Electrical and Mechanical Parts made from copper-base spring metals

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*Pat. Pending.

(Continued on Page 2, Col. 2)

COPPER ALLOY BULLETIN

CAUSES OF CORROSION

This article is one of a series of discussions by C. L. Bulow, research chemist of the Bridgeport Brass Company.

EFFECT OF STRESS ON CORROSION

Effect of Cold or Hot Working

The working of metals either at room temperature or at elevated temperatures may lead to the development of cracks in the metal. Those metals which develop cracks at room or moderate temperatures are said to be in the language of the metallurgist "cold-short"; the metals which develop cracks when worked at elevated temperatures are said to be "hot-short". Many metals must be worked in a limited range of temperature in order to avoid cracking.

Effect of High Pressures

Tensile stresses high enough to rupture cylinders, tubes, pipes, and tank walls may result from high pressures such as developed by high pressure gases (overheated boiler tubes, etc.) or during the freezing of water. Ruptures in tubing or pipe in this manner are characterized by a bulge containing a longitudinal split or crack. If the material is not ductile at the temperature and pressure at which rupture or cracking occurs, the bulge will be absent. A longitudinal flaw in a ductile material will also contribute toward the elimination of the characteristic bulge.

Effect of Changes in Microstructure

Phase changes occurring within a crystal grain may result in large volume changes and the formation of micro cracks. This may be encountered: (1) during the heat treatment of steel, (2) in certain zinc die casting alloys at moderate temperatures, (3) in shrinkage cracks in castings, (4) during the allo-tropic change of tin from ordinary tin (beta) to gray tin (alpha) at temperatures below 18° C., etc.

Corrosion fissuring or cracking may sometimes develop in certain media without the stimulus of stress. In some metals the attack follows a network of impurities existing at the grain boundaries or at boundaries of the primary grains. For example, an alloy in the vicinity of a grain boundary might be depleted of one of the alloying elements such as occurs during the heat treating of non-stabilized stainless steel.

Effect of Molten Metals

Molten metals (commonly low melting point alloys and elements) may penetrate tensile stressed ferrous and non-ferrous metals along the grain boundaries (intercrystalline penetration) with the production of cracks. The familiar "mercurous nitrate test" for detecting undesirable stresses depends upon the action of liquid mercury penetrating the stressed brass. The "fire-cracking" of certain leaded copper-base alloys appears to depend upon the combined action of high internal stresses in cold worked metal (strain hardened) and a temperature high enough to melt the insoluble lead but not high enough to relieve the stress (usually developed by slight amounts of cold-working or during cutting operations carried out with dull tools).

Effect of Hydrogen at Elevated Temperature

Certain gases at elevated temperatures may penetrate or diffuse through the metal and react with impurities or alloying elements with the production of fissured or embrittled metal. Hydrogen reacting with carbon in steel with the formation of methane within the metal: $2H_2 + C \rightarrow CH_4$ or hydrogen reacting with copper oxide in certain types of copper with the formation of water vapor:

$$H_2 + Cu_2O \rightarrow 2Cu + H_2O$$

are samples of this type of embrittlement. Another example is the hydrogen embrittlement of steels by nascent hydrogen during pickling and plating operations.

Wide Range of Copper-Base

(Continued from Page 1)

acting electronic applications and special operations such as hydrogen brazing of steel and sealing-in glass. Bridgeport's oxygen-free copper has been found superior for the manufacture of high-frequency vacuum tube parts because of its purity and freedom from surface scratches and flaws.

Technical Service Department

Bridgeport's Technical Service Department, composed of an experienced group of practical men, works closely with customers in studying the possibilities of copper-base engineering alloys as applied to their products. Contact the Technical Service Department through the nearest Bridgeport office and write for the 128-page Technical Handbook, which contains comprehensive information about Bridgeport's engineering alloys as well as standard mill products.

NEW DEVELOPMENTS

This column lists items manufactured or developed by many different sources. None of these items has been tested or is endorsed by the Bridgeport Brass Company. We will gladly refer readers to the manufacturer or other sources for further information.

New Inside Micrometer has been announced which manufacturer claims will measure bores without removing boring bars. Standard range of sizes is from 8 to 28 inches and covers bar diameters from 4 to 8 inches. **No. 732**

Bench Model Punch Press recently developed is said to be equally adaptable for stamping, marking, punching, crimping, riveting and other high speed production operations. Operates at 285 revolutions per minute and is driven by 1725-revolutions-per-minute electric motor. **No. 733**

New Continuous Bar Marker is designed, according to manufacturer, to mark bar material permanently throughout its length. Bars are fed between rolls from which they are ejected after marking. Automatic in operation, machine is said to be capable of handling flat, square, round, hexagonal and structural or extruded shapes at speeds of 70 to 210 ft. per minute. **No. 734**

Metal Hardness Gage recently announced is said to accurately determine hardness variations in copper, brass, aluminum and their alloys as well as other nonferrous metals. Two models available, one with readings from 1 to 29, the other with penetrator of greater sensitivity and shorter hardness range. **No. 735**

Electronic Micrometer is available which, it is claimed, will provide precise thickness measurement in laboratory, plant and shop to assure accurate readings to 0.00005-inch on production testing lines. Said to be capable of measuring thickness of compressible or noncompressible materials as well as conducting or nonconducting materials. **No. 736**

New Automatic Drilling Spacer is said to permit rapid precision drilling of holes in metal parts without use of jigs. Device consists of heavy flat table which moves either laterally or longitudinally on its base under fixed drill spindle. **No. 737**

Universal Dial Indicator having dial perpendicular to axis of body, is claimed by manufacturer to be particularly suitable for general machine shop, tool room and inspection work. Adaptable for use in jig borer and in certain drill press and milling machine applications where position of dial improves readability with resulting accuracy. **No. 738**

Precision Angle Square, capable of checking accuracy of work within 0.0001-inch, has indicator, manufacturer announces, that instantly shows error on dial and indicates amount of correction required. Recommended for precision work in tool and die shops, machine shop and testing laboratories. **No. 739**

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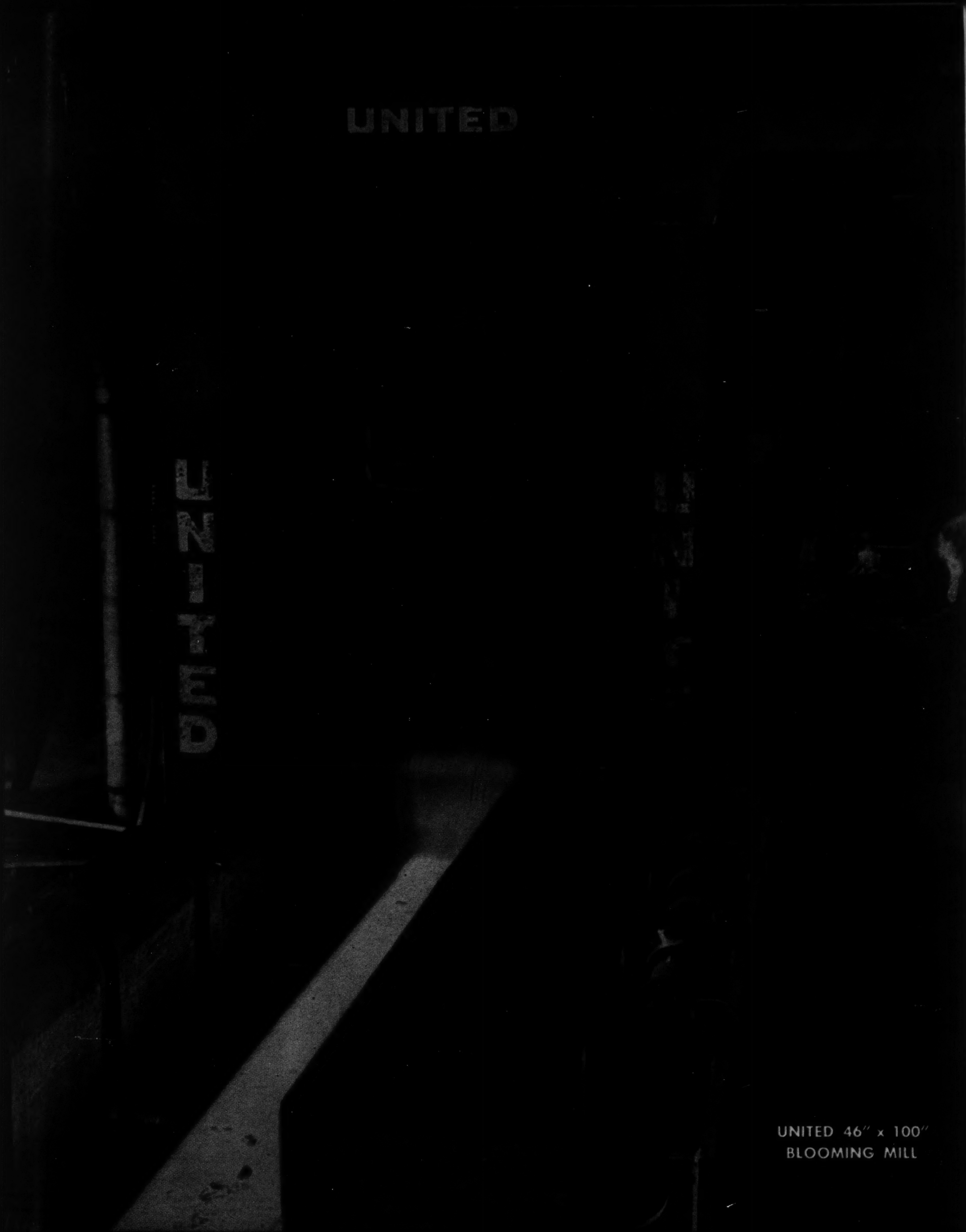

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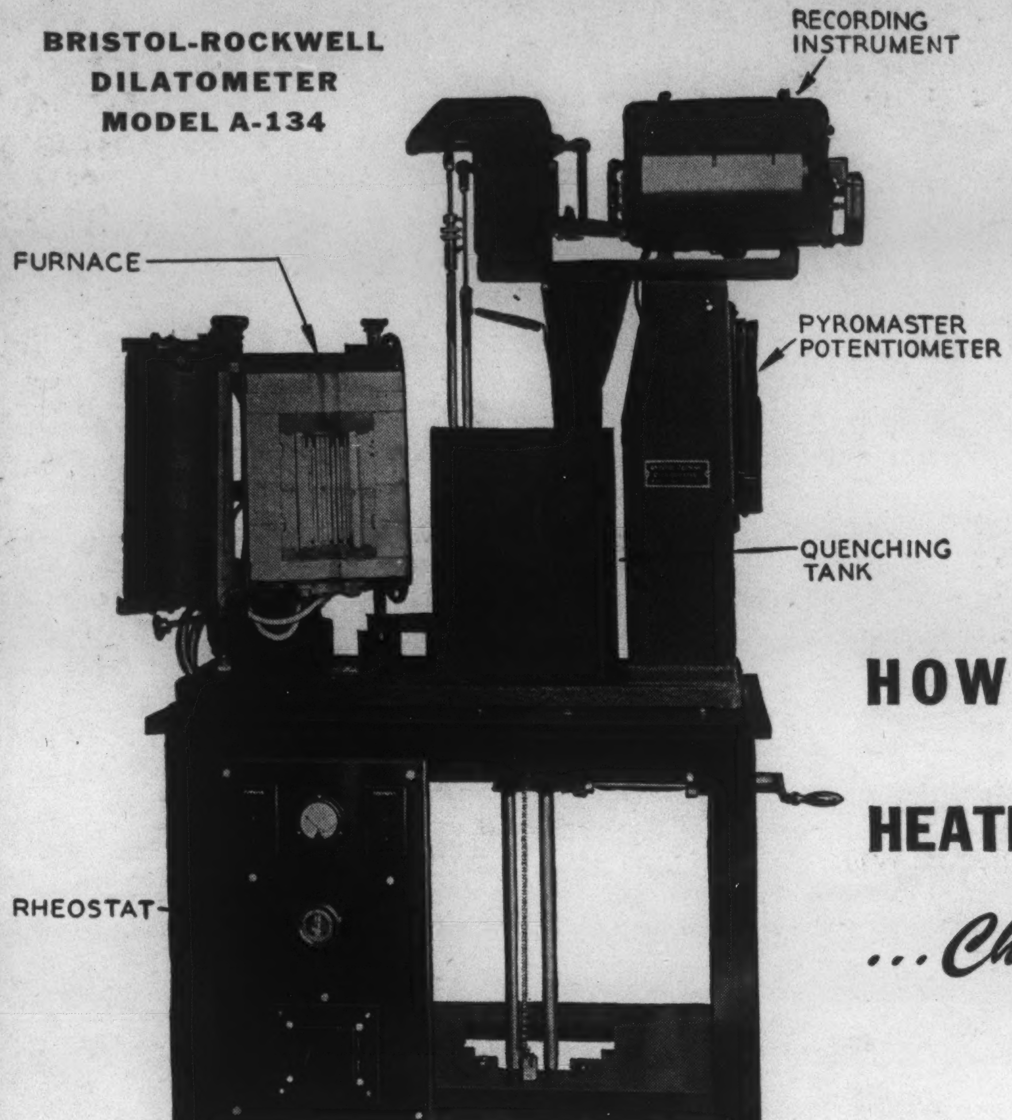

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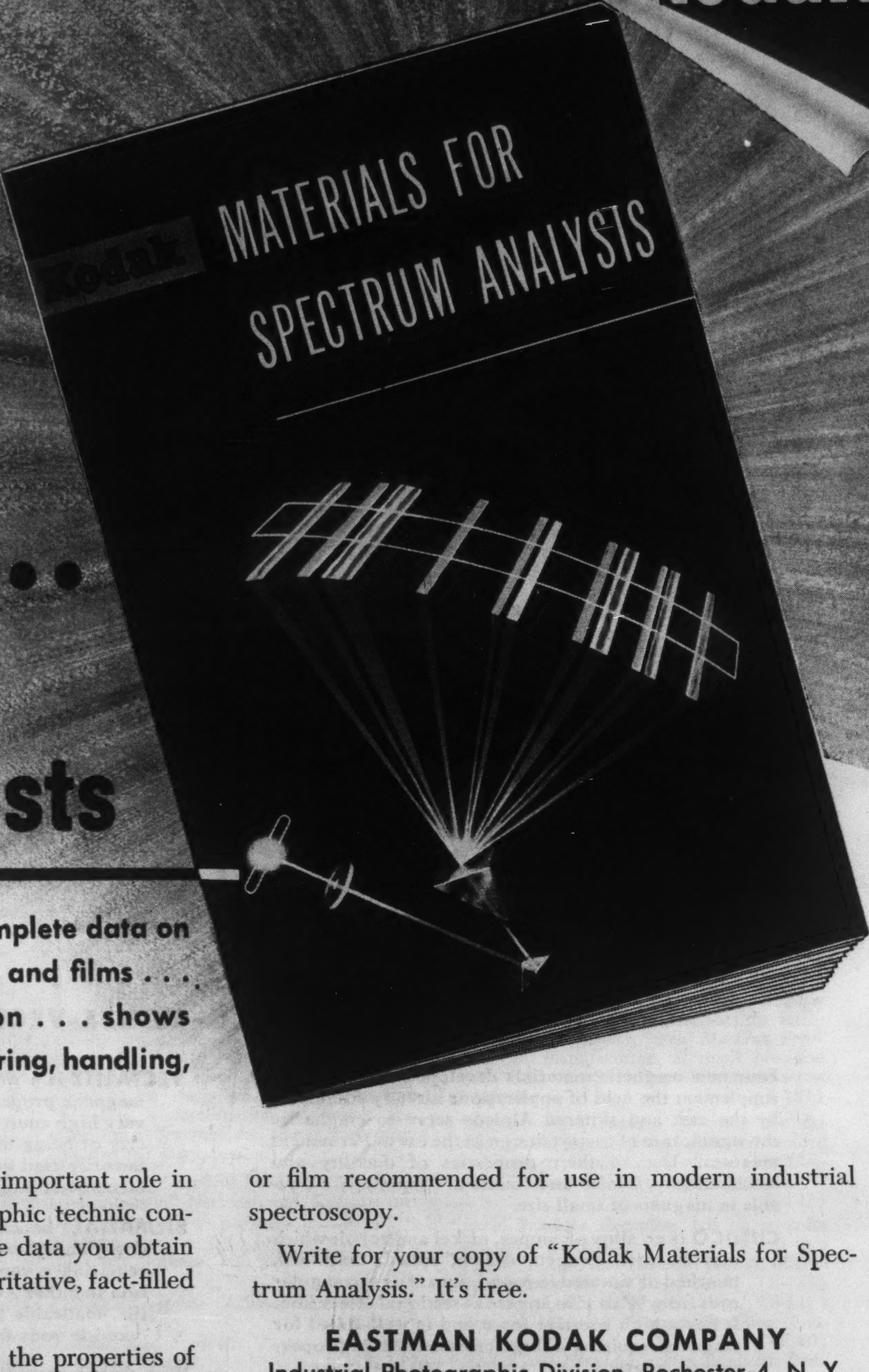

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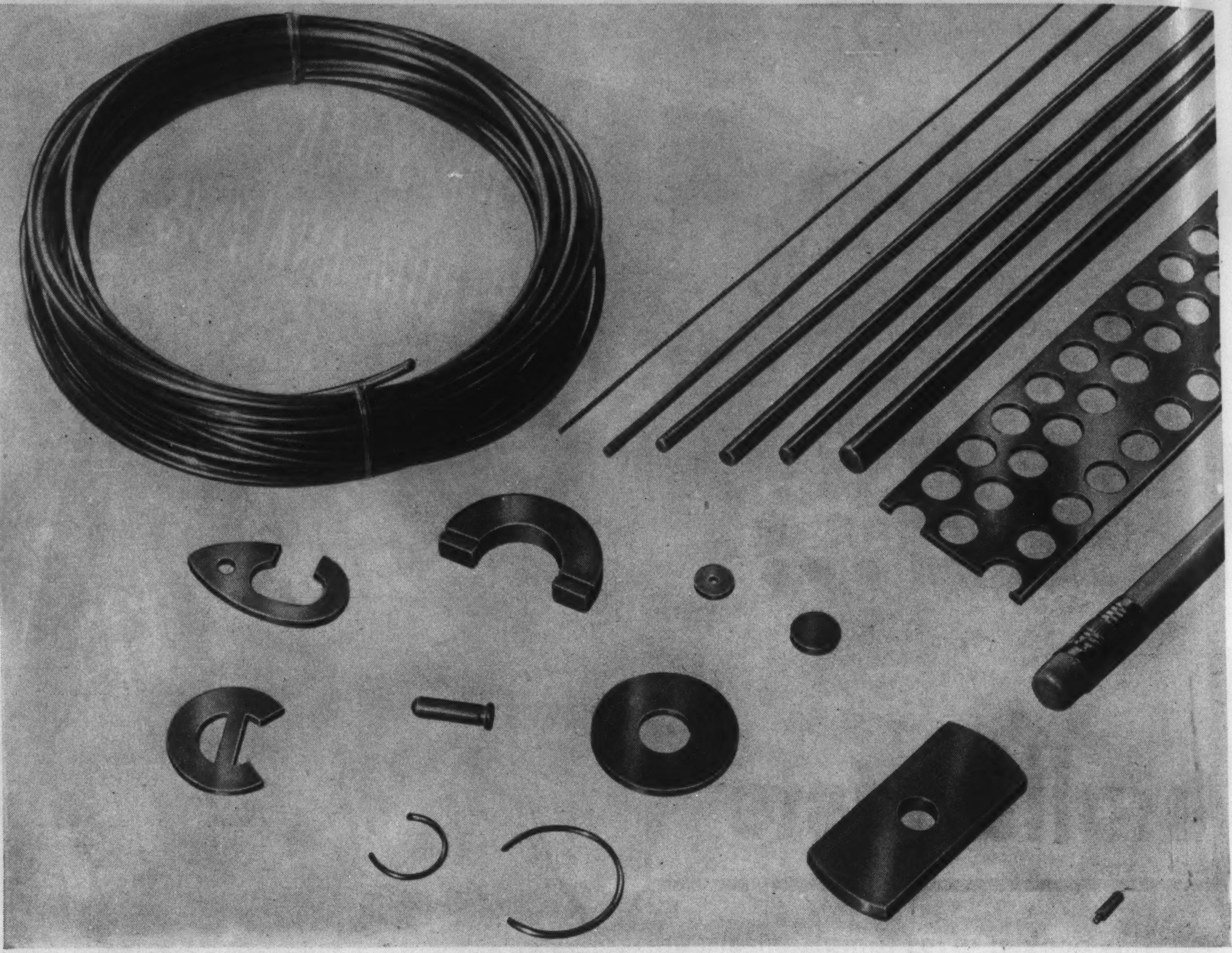

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Manufacturers' Literature

Materials

Steels and Irons

Alloy Steels. Two types of chromium-nickel alloy steels, Nos. 5-317 and 158, that meet specific requirements are discussed in a 12-page booklet of *Carpenter Steel Co.* Applications and physical properties are included. (A-79)

Tool Bits. Allegheny Ludlum Steel Corp. (A-30)

Alloy Steel. Bissett Steel Co. (A-77)

Cold Finished Bar Steel. Bliss & Laughlin, Inc. (A-61)

High Strength, Low Alloy Steel. Inland Steel Co. (A-45)

Special Tool and Die Steels. Kropp Forge Co. (A-78)

Nonferrous Metals

Sheet, Wire and Rod. The composition, properties, tolerances and sizes of nickel silver and phosphor bronze sheet, wire and rod are presented in tabular form in a 6-page folder of *Seymour Mfg. Co.* (B-65)

Cerium. Cerium Metals Corp. (B-63)

Bronze for Bearings. Johnson Bronze Co. (B-56)

Free-Machining Aluminum. Reynolds Metals Co. (B-57)

Plastics and Related Materials

Plastics. Instructions on how to use Urac 110 with Hardener WF-101, a white, dry urea-formaldehyde resin to be used in formulations for hot press flour extended plywood adhesives, are presented in a 4-page bulletin of *American Cyanamid Co.* (C-75)

Deep-Drawn Laminated Shapes. This 4-page bulletin, No. AK-101, describes and illustrates deep-drawn laminated plastic shapes made to specification by *Andover Kent.* (C-76)

Plastic Service. American Insulator Corp. (C-35)

Nonmetallic Basic Materials. Continental-Diamond Fibre Co. (C-72)

Plastics. Dow Chemical Co., Plastics Div. (C-12)

Plastics. General Electric Co. (C-37)

Phenolic Resins. Reichhold Chemicals, Inc. (C-74)

Plexiglas. Rohm & Haas Co. (C-30)

Plastics. Westinghouse Electric Corp. (C-19)

Other Nonmetallic Materials

Felt Insulation. Data Sheet No. 3, published by the *American Felt Co.*, discusses "K" Felt, a combination of kapok and other fibers designed for sound absorption and thermal insulation. (D-21)

Carbon and Graphite Products. The many applications of National and Karbate carbon and graphite products are listed by *National Carbon Co., Inc.* in a 20-page, illustrated bulletin, No. M-8000-C. (D-22)

Colloidal Graphite. Acheson Colloids Corp. (D-19)

Rubber and Synthetic Parts. Continental Rubber Works. (D-17)

Metallized Glassware. Corning Glass Works. (D-8)

Sapphire Products. Aurele M. Gatti, Inc. (D-18)

Synthetic Jewels. Linde Air Products Co. (D-14)

Fluorine. Pennsylvania Salt Manufacturing Co. (D-20)

Wheel Bearing Greases. The Texas Co. (D-16)

Please Use the Coupon on Page 1552

Parts and Metal-Forms

Bronze Alloy Castings. This illustrated, 46-page, spiral-bound book published by *American Manganese Bronze Co.* presents complete data on the compositions, characteristics, specifications and applications of bronze casting alloys. (E-119)

Wire and Tubing. Specifications are included in this 8-page, illustrated bulletin describing metal shielded wire and accurately drawn seamless tubing produced by *Precision Tube Co.* (E-120)

Small Precision Parts. This 4-page bulletin profusely illustrates and describes the facilities of the *Specialty Screw Machine Products Co.*, manufacturers of small precision parts made on Swiss type automatic screw machines. (E-121)

Stainless Steel Tubing. A guide for the selection of seamless and redrawn welded stainless steel tubing is offered by *Summeril Tubing Co.* in a 4-page bulletin. (E-122)

Jewel Bearings. Complete data on sapphire and ruby jewel bearings are presented in a 12-page, illustrated bulletin, No. A, offered by the *John Worley Jewel Co.* (E-123)

Tubing. Agaloy Tubing Co. (E-111)

Precision Casting. Bergen Precision Castings, Inc. (E-60)

Rolled and Forged Circular Products. Bethlehem Steel Co. (E-112)

Duplex Tubing. Bridgeport Brass Co. (E-113)

Tubular Parts. Calumet & Hecla Consolidated Copper Co., Wolverine Tube Div. (E-80)

Magnets. General Electric Co. (E-1)

Self-Lubricating Bushings. Graphite Metallizing Corp. (E-114)

Forgings. Harrisburg Steel Corp. (E-103)

Weldments. Lukenweld, Inc. (E-109)

Designing for Die Casting. New Jersey Zinc Co. (E-24)

Oilless Bearings. Nolu Oilless Bearing Co. (E-98)

Seamless Steel Tubing. Ohio Seamless Tube Co. (E-88)

Methods and Equipment

In this Manufacturers' Literature INDEX, new bulletins are given complete reviews, and previously described older bulletins are merely listed in their proper places.

Steel Forgings. Pittsburgh Forgings Co. & Greenville Steel Car Co. (E-99)

Etched and Lithographed Metal. Premier Metal Etching Co. (E-100)

Welded Boiler Tubes. Joseph T. Ryerson & Son, Inc. (E-89)

Precision Casting by the Lost Wax Process. I. Shor Co. (E-116)

Pipe and Fitting Materials Chart. Tube Turns, Inc. (E-117)

Roll Neck Bearings. Westinghouse Electric Corp. (E-118)

Coatings and Finishes

Aluminum Coating. This 4-page, illustrated data sheet, No. 7-16-100, discusses Alodine, a rust proofing process for aluminum and its alloys, produced by *American Chemical Paint Co.* (F-25)

Packaging Metal Parts. The many applications of Plastic Peel, a hot-melt strippable plastic for packaging metal parts, are discussed in an 8-page illustrated bulletin of *Hercules Powder Co.* Specifications are included. (F-26)

Plastic Coating. Seal-Peel, a plastic coating for protecting tools, gages, etc., is discussed in a 4-page, illustrated pamphlet of *Seal-Peel, Inc.* (F-27)

Silicone Varnish. Dow Corning Corp. (F-21)

Seamless Coatings and Linings. Gates Engineering Co. (F-22)

Protective Finishes. Mitchell-Bradford Chemical Co. (F-9)

Coatings, Compounds, Etc. National Engineering Products, Inc. (F-23)

Protective Strip Coatings. Tennessee Eastman Corp. (F-24)

Melting, Refining and Casting

Induction Heating and Melting. The principles and advantages of using high-frequency induction furnaces for melting and heating are discussed in an 8-page, illustrated bulletin, No. 27, published by *Ajax Electrothermic Corp.* (G-42)

Graphite Electrodes. Complete data on graphite electrodes for electrothermic and electrolytic purposes are presented in a 4-page, illustrated booklet of *International Graphite & Electrode Corp.* (G-43)

Casting Sealant. Monsanto Chemical Co., Plastics Div. (G-10)

Rolling, Wire Drawing and Extruding

Rolls and Rolling Mill Equipment. This 32-page bulletin profusely illustrates and describes the facilities of the *United Engineering & Foundry Co.,* designers and makers of rolls and rolling mill equipment. (H-5)

Pressworking, Stamping, Forging, Powder Metal Forming

Forging Hammers. A complete line of Lobdell-Nazel electropneumatic forging hammers, produced by the *Lobdell Co.,* is profusely illustrated and described in a 24-page bulletin. (J-39)

Precision Brakes. Completely redesigned Di-Acro precision brakes, and their many advantages, are described and illustrated in a 4-page bulletin of *O'Neil-Irwin Mfg. Co.* (J-40)

Presses. Air Hydraulics, Inc. (J-30)

Hydraulic Presses. Hydraulic Press Manufacturing Co. (J-31)

Presses, Shears, Etc. Niagara Machine & Tool Works. (J-32)

Die Sets. Standard Machinery Co. (J-27)

Bending and Punching Calculator. Verson Allsteel Press Co. (J-37)

40-Ton Press. Watson-Stillman Co. (J-23)

Machining and Grinding

Tapping Machines. Complete data on tapping machines are offered by *Cleveland Tapping Machine Co.* in a 28-page, illustrated bulletin. (L-135)

Carbide Tipped Tools. A revised price list of standard sizes and shapes of Meehanite single-point, carbide tipped tools is included in a 4-page, illustrated bulletin of *Cooper-Bessemer Corp.* (L-136)

Drilling and Tapping Small Parts. Bulletin No. 31, 16 pages, describes and illustrates the Ettco-Emrick system for fast, low-cost multiple drilling and tapping of small parts. *Ettco Tool Co., Inc.* (L-137)

Cemented Carbides. A complete line of cemented carbide products produced by *Kennametal, Inc.* is presented in a 56-page, illustrated catalog, No. 46. Specifications and prices are included. (L-138)

Abrasive. This 16-page, illustrated booklet published by the *Norton Co.* presents complete data on Norbide, a boron-carbide abrasive. (L-139)

Soluble Oil. Complete data on the use of soluble oil in cutting, machining and grinding operations on ferrous and nonferrous metals are presented in a 20-page, illustrated booklet of *Oakite Products, Inc.* (L-140)

Precision Lathes. A wide variety of precision lathes, and their specifications, are described and illustrated in an 8-page bulletin, No. 25, of *South Bend Lathe Works.* (L-141)

Carbide Tools and Blanks. Engineering data and price list of a complete line of carbide tools and blanks are presented in a 28-page, illustrated bulletin, No. VR-400, offered by *Vascoloy-Ramet Corp.* (L-142)

Presses, Saws, Etc. This 4-page, illustrated bulletin of *Walker-Turner Co.* describes drill presses, radial drills, radial cut-offs, band saws and grinders, and includes prices. (L-143)

Drilling and Tapping Machines. Barnes Drill Co. (L-51)

Abrasive Finishing. Behr-Manning Corp. (L-118)

Flute Grinder. Edward Blake Co. (L-125)

Grinding Machinery. Bridgeport Safety Emery Wheel Co., Inc. (L-126)

Coolant Filters. Briggs Filtration Co. (L-127)

Grinding Data Book. Carborundum Co., Refractory Div. (L-24)

Drill Chip Breaker. Continental Tool Works. (L-119)

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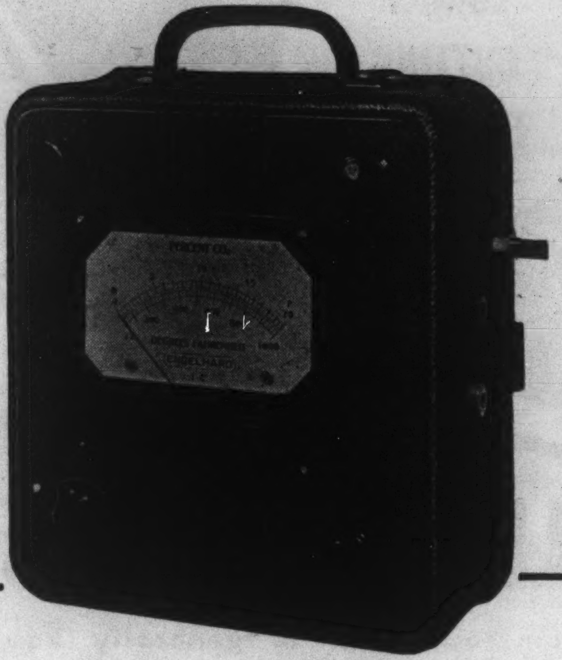

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Openside Planers. G. A. Gray Co. (L-62)
Tool Grinders. Hammond Machinery Builders. (L-91)
Electric Grinders and Buffers. Hisey-Wolf Machine Co. (L-130)
Carbide Miller. Kearney & Trecker Corp. (L-110)
Grinding Wheels. Mid-West Abrasive Co. (L-123)
Wet Belt Machining. Porter-Cable Machine Co. (L-133)
Cutting Fluids. D. A. Stuart Oil Co., Ltd. (L-115)

Heat Treating

Sub-Zero Industrial Units. Specifications are included in this 4-page bulletin, which describes and illustrates 5- and 11-cu.-ft. sub-zero industrial units, produced by *Bowser, Inc.* (M-102)

Heat Treating Furnaces. A novel way of describing their complete line of heat treating furnaces is presented by *Furnace Engineers, Inc.* in an 8-page, illustrated bulletin. (M-103)

Atmosphere Generator. The Hyen automatic atmosphere generator for hardening, brazing and sintering all medium and high carbon steels without decarburization is described and illustrated in a single sheet of *Lindberg Engineering Co.* (M-104)

Furnaces and Soaking Pits. A wide variety of furnaces and circular soaking pits produced by the *Salem Engineering Co.* are described and illustrated in a 16-page bulletin. Charts and tables are included. (M-105)

Roller Hearth Furnaces. Complete data on prepared atmosphere roller hearth furnaces for ferrous and nonferrous bars, tube and strip are presented in a 4-page, illustrated bulletin, No. SC-132, of *Surface Combustion Corp.* (M-106)

Heat Treating Literature. Ajax Electric Co., Inc. (M-76)
Heat Treatments. Carnegie Illinois Steel Corp. (M-94)
Induction Heating. Electric Arc, Inc. (M-92)
Induction Heating Equipment. Federal Telephone & Radio Corp. (M-25)
Refrigeration and Air Conditioning Equipment. General Electric Co. (M-1)
Quenching Press. Gleason Works. (M-95)
Furnace Controls. Hays Corp. (M-86)
Carburizer-Nitrider Furnace. Hevi-Duty Electric Co. (M-100)
Automatic Conveyor Equipment. A. F. Holden Co. (M-96)
Furnaces. K. H. Huppert. (M-75)
Induction Heating. Induction Heating Corp. (M-61)
Dielectric Heater. W. T. La Rose & Associates. (M-99)
Induction Heating. Lepel High Frequency Laboratories, Inc. (M-68)
Ammonia. Mathieson Alkali Works, Inc. (M-93)
Salt Baths. Park Chemical Co. (M-20)
Pusher Type Furnaces. W. S. Rockwell Co. (M-88)
Specifications and Heat Treating Chart. Sunbeam Corp. (M-43)
Salt Bath Furnaces. Upton Electric Furnace Div., Commerce Pattern Foundry & Machine Co. (M-98)

Heat-Treating Atmospheres. Westinghouse Electric Corp. (M-59)

Refractories and Insulation

Refractory. Vitrobond, a highly refractory, self-vitrifying, high temperature furnace, fire-box and crucible coating, is discussed in a 4-page, illustrated bulletin of *Johnson Fuller Co.* (N-26)

Refractory Coating. Brickseal Refractory Co. (N-23)

Refractory. Ironton Fire Brick Co. (N-20)

Resinous Cement. Nuken Products Corp. (N-22)

Refractory Surfacing Mortar. Quigley Co., Inc. (N-24)

Refractories. Charles Taylor Sons Co. (N-21)

Refractory Concrete. Universal Atlas Cement Co. (N-18)

Welding, Joining, Fastening

Flame Scarfing Apparatus. A complete line of hand apparatus for flame scarfing is presented in a 4-page, illustrated bulletin of *Air Reduction Sales Co.* (O-161)

Resistance Welding Alloys. Users of Ampcoloy resistance welding alloys will find useful a one-page comparative chart, and a list of physical properties of RWMA alloys, one page, published by *Ampco Metal, Inc.* (O-162)

Steel Fasteners. A complete stock list of stainless steel commercial and aircraft nuts, bolts, rivets, screws, etc., produced by *Anti-Corrosive Metal Products Co., Inc.*, is presented in an 8-page folder (O-163)

Fasteners. The many advantages and applications of spring-locking fasteners for use on plywood, plastic and metal products, are offered by *Lion Fastener, Inc.* in a 4-page, illustrated bulletin, No. 462. (O-164)

Solder Wire. Alpha Metals, Inc. (O-145)

Welding Magnesium. American Magnesium Corp. (O-135)

Welding. American Welding & Manufacturing Co. (O-155)

Stainless Steel Electrodes. Arcos Corp. (O-126)

Gas Cutting and Welding Apparatus. Black Manufacturing Co. (O-146)

Fasteners. Dzus Fastener Co., Inc. (O-73)

Self-Locking Nuts. Elastic Stop Nut Corp. of America. (O-147)

Low Temperature Welding. Eutectic Welding Alloys, Inc. (O-8)

Repairs by Arc Welding. General Electric Co. (O-10)

Engine-Driven Arc Welder. Hobart Brothers Co. (O-121)

Electrodes and Gas Welding Rods. Hollup Corp. (O-148)

Welded Design. Lincoln Electric Co. (O-101)

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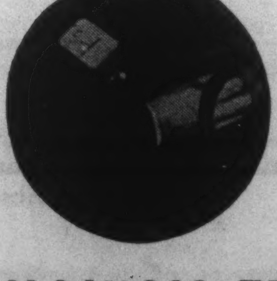

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Stud Welder. Nelson Sales Corp. (O-159)
Welding. Powder Weld Co. (O-80)
Flash Welders. Progressive Welder Co. (O-79)
Resistance Welding Data. Sciaky Brothers. (O-125)
Carbon Arc Welding. Speer Carbon Co. (O-152)
Welding Pressure Vessels. Sperry Products, Inc. (O-160)
Portable Welders. Taylor-Winfield Corp. (O-153)
Rivet Remover. Topflight Tool Co. (O-154)
Hard Facing Alloys. Wall-Colmonoy Corp. (O-144)

Cleaning and Pickling

Metal Cleaning Compounds. A complete list of Ahcoloid cleaners for soak tanks, electrocleaning, power washers, etc., is presented in an 8-page bulletin published by *Apothecaries Hall Co.* (P-54)

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Blast Cleaning Machine. American Foundry Equipment Co. (P-5)
Aluminum Flux. Apex Smelting Co. (P-51)
Weld Cleaning. Chicago Manufacturing & Distributing Co. (P-53)
Steam Cleaner. Homestead Valve Manufacturing Co. (P-52)
Cleaning. MacDermid, Inc. (P-21)
Washing Machines. Optimus Equipment Co. (P-49)
Grit Blast. Sanstorn Manufacturing Co. (P-50)
Diesel Engine Overhaul. Turco Products, Inc. (P-46)

Plating and Finishing

Lead-Tin Alloy Plating. General Chemical Co. (Q-40)
Automatic Conveyors. Hanson-Van Winkle-Munning Co. (Q-43)
Phosphate Coatings. Neilson Chemical Co. (Q-28)
Temperature Control in Electroplating. Taylor Instrument Co. (Q-46)
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Remote Indication and Control Systems. Complete data on direct current remote indication and control systems, and their many applications, are presented in a 12-page, illustrated bulletin, No. 14B6641, of *Allis-Chalmers Mfg. Co.* (R-60)

Time Switches. Six applications of special-built time switches for the volume user are presented in a 4-page, illustrated bulletin, No. T-55, of *Automatic Temperature Control Co., Inc.* (R-61)

Inkless Recorder. This 20-page bulletin, No. M-100, presents the principle and operation of the rotary stylus sweep balance recorder, produced by *Connecticut Telephone & Electric Div., Great American Industries, Inc.* Illustrated applications are included. (R-62)

Measuring and Recording Equipment. A mass spectrometer, electrical computer and vacuum leak detector are described and illustrated in a 6-page folder of *Consolidated Engineering Corp.* (R-63)

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Immersion Pyrometer. The new Pyro immersion pyrometer for nonferrous metals is described and illustrated in a 4-page bulletin, No. 150, offered by *Pyrometer Instrument Co.* Specifications are included. (R-67)

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Portable Pyrometers. Wheelco Instruments Co. (R-57)

Testing and Inspection

Testing Machine. Specifications and full details of the Sonntag 10,000-in.-lb. rotating beam fatigue machine, Model SF-10R, are presented in a 4-page, illustrated bulletin, No. 205, published by *Baldwin Locomotive Works, Baldwin Southwark Div.* (S-65)

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Hydraulic Pumps, Valves, Etc. Hydro-Power, Inc. (T-135)

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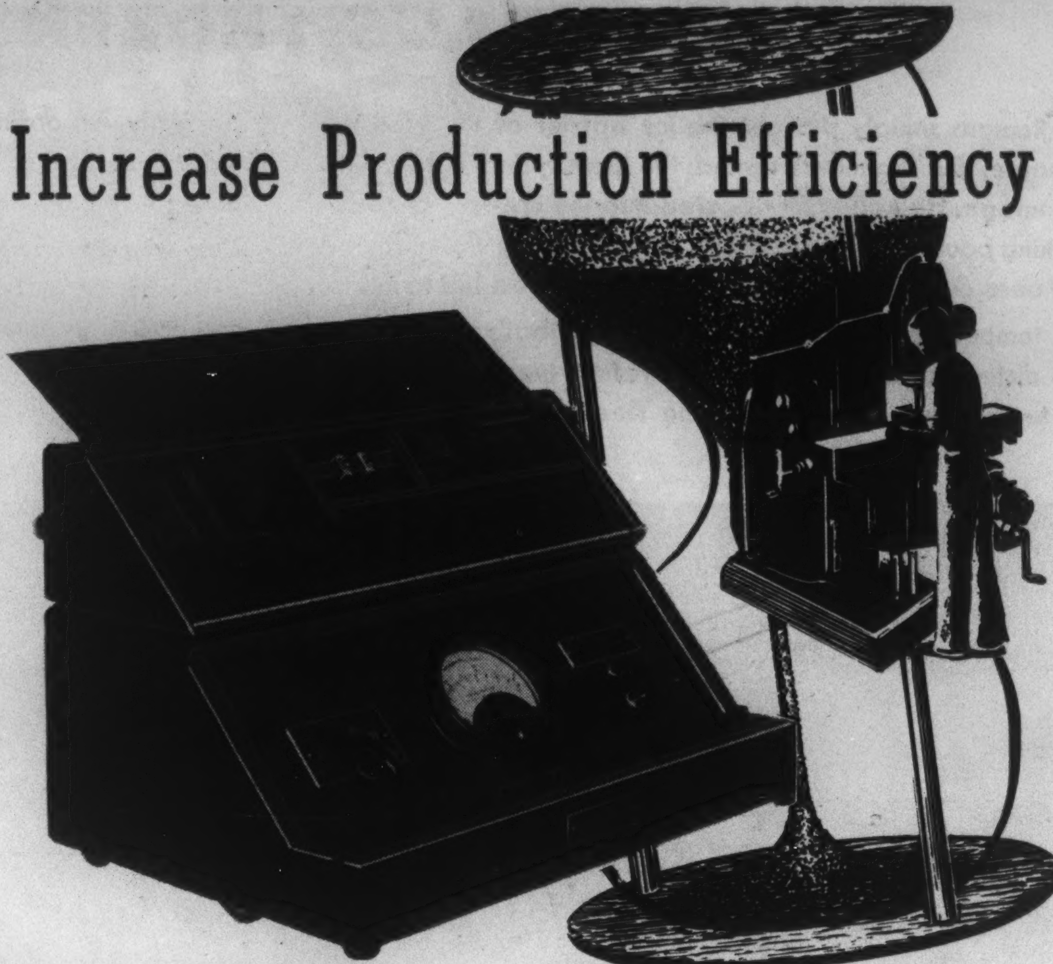

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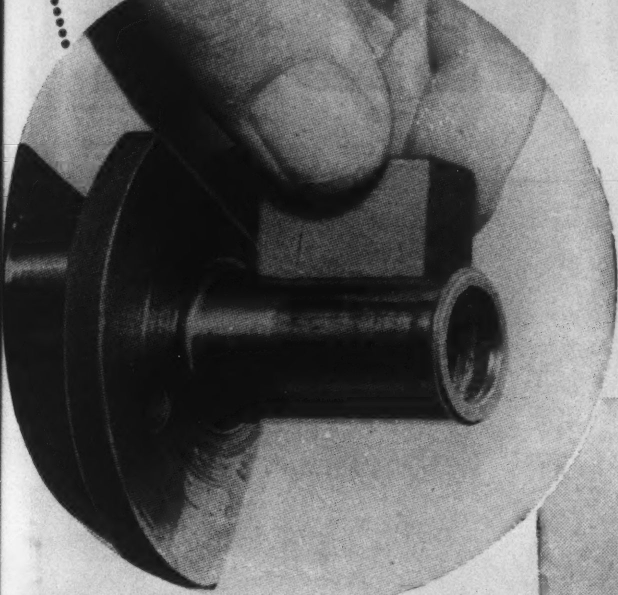
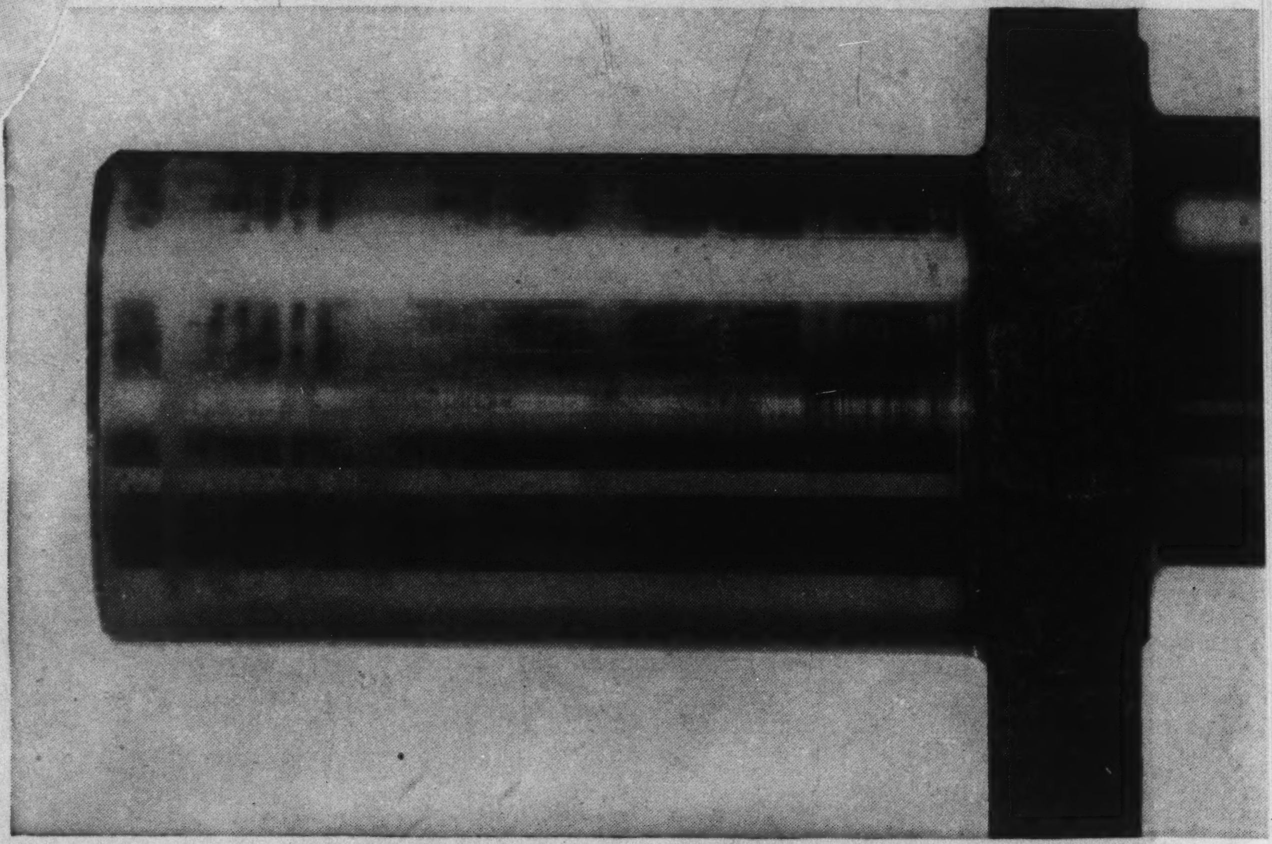
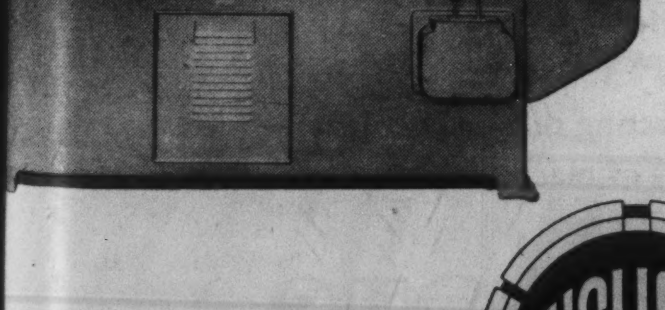
how SUPERFINISH proves a point



In a few seconds you can demonstrate the difference between a sanded and a Superfinished surface. Here, on a small crankshaft for an outboard motor, a Superfinishing stone curved to the exact radius of the part is held by hand and oscillated as the shaft is rotated. In a matter of seconds, as shown below, enough "smear metal" (softened by grinding heat) is removed to reveal the grinder ridges and flats, feed spirals, chatter marks and other defects injurious to bearings. Because the Superfinishing stone is rigid, it corrects *geometrical shape,* whereas emery cloth, being pliable, merely polishes the surface.





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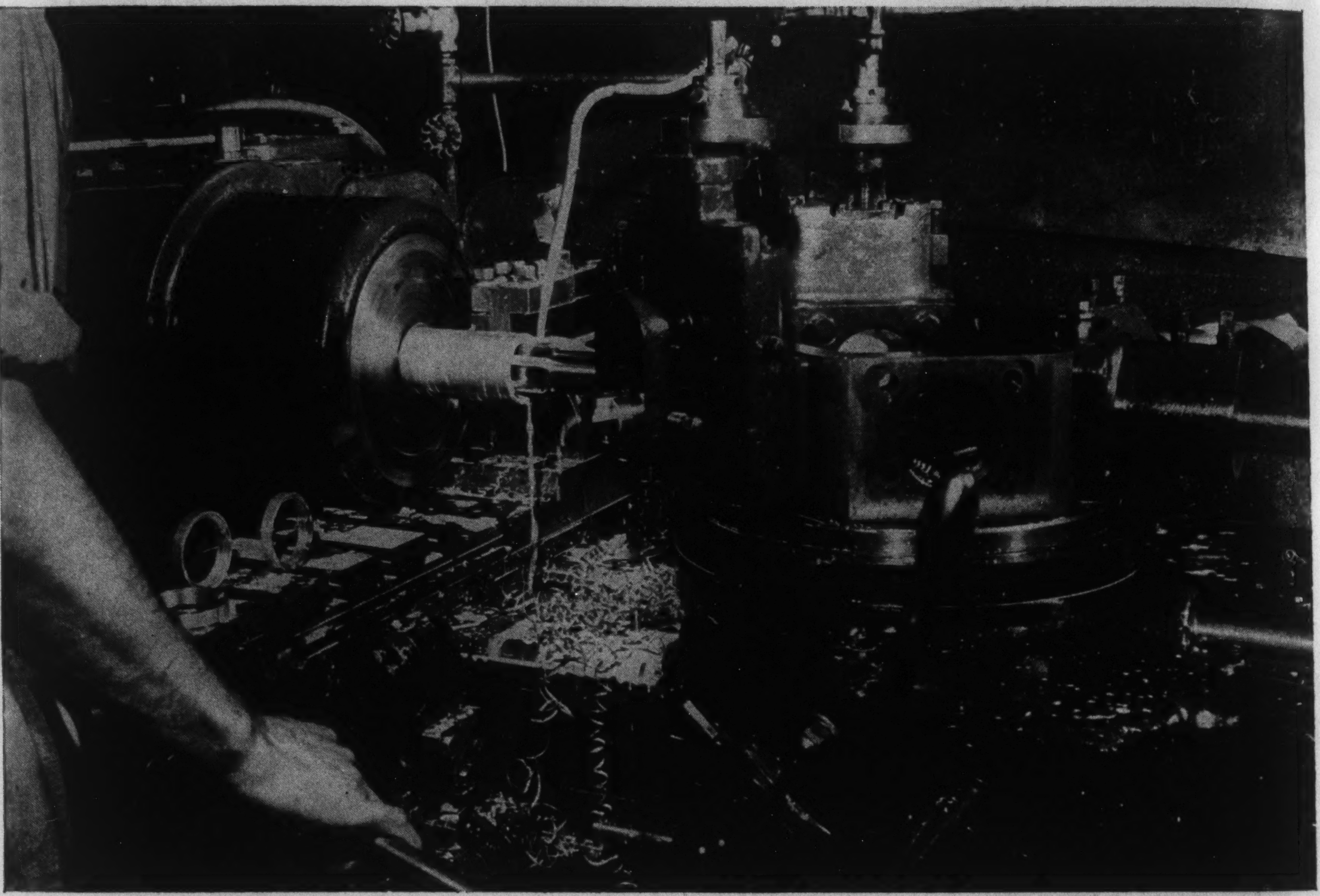

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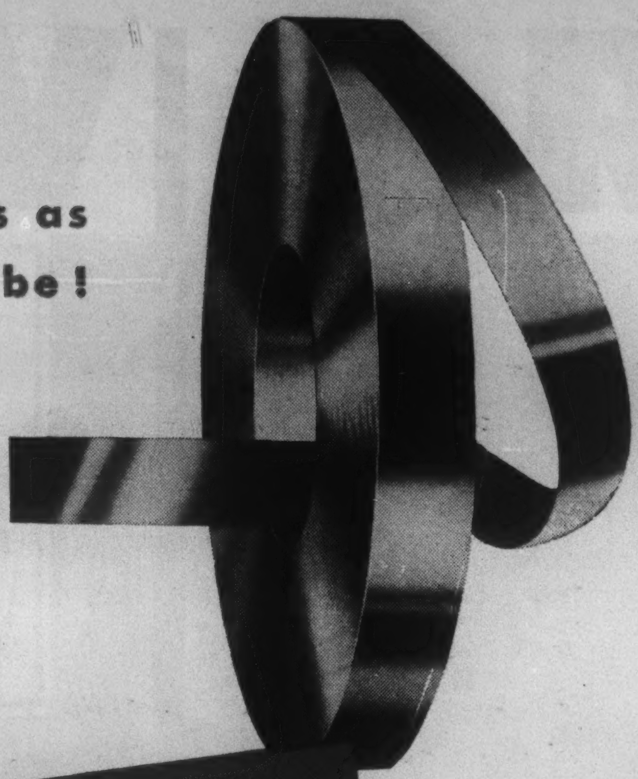

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LIGHT-GAUGE COLD-ROLLED

alloy strip

This never-before-available cold-rolled alloy strip in extra-thin gauges may be your cue to major improvements in process and product. The uniformity and accuracy which characterize all CMP Thinsteel products are inherent in this newest development. You will use CMP Alloy Strip* to gain these advantages over carbon steels:

1. **Weight can be reduced without loss of strength.**
2. **Keep the same weight; greatly increase strength.**
3. **High tensile values are obtainable in certain alloy Thinsteel grades.**
4. **Flexing tests demonstrate unusual fatigue resistance.**
5. **Greater resistance to atmospheric corrosion.**

CMP men thoroughly familiar with metal fabrication will answer your inquiry.

**depending on grade*

CMP

**pioneer and still
first in precision
cold-rolling**

**THE COLD METAL
PRODUCTS CO.**
YOUNGSTOWN 1, OHIO

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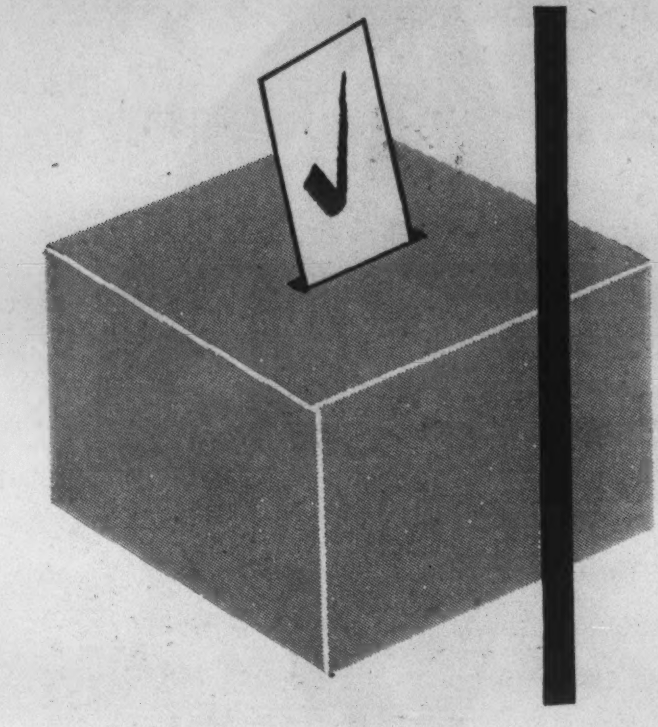
THINSTEEL
CMP
PRECISION COLD ROLLED
GIVES MAXIMUM PRODUCTION PER TON



a vote of confidence for MODERN PLASTICS

According to the figures, Modern Plastics' readers have turned in an overwhelming vote of confidence for Modern Plastics.

They have demonstrated again that Modern Plastics is the vital medium in the plastics field.

For Modern Plastics paid readers, now more than 18,000 strong, continue to *stay with* Modern Plastics. According to the latest returns, Modern Plastics' percentage of renewed subscriptions is 78.39%. This phenomenal renewal rate gives Modern Plastics a staying power unique in the field.

What Is a Renewal Rate?

The renewal rate of a magazine is *voluntary evidence* that the magazine is indispensable to the subscriber. The renewal rate of a publication is the heart and core of its circulation. Paid and renewed circulation is readership. The renewal rate demonstrates that readership in action.

Here are Modern Plastics' renewal rates over a period of years:

At June 30, 1943 for year ending Oct. '42	**65.34%**
At Dec. 31, 1943 for year ending Oct. '43	**65.65%**
At Oct. 31, 1944 for year ending Apr. '44	**67.07%**
At Apr. 30, 1945 for year ending Oct. '44	**73.99%**
At Oct. 31, 1945 for year ending Apr. '45	**77.07%**
At Apr. 30, 1946 for year ending Oct. '45	**78.39%**

These rates tell the whole story. Modern Plastics' percentage of renewed subscriptions is unsurpassed and unduplicated. And it is steadily rising.

Why Is Modern Plastics Able to Keep So High a Percentage of Its Readers?

It is because Modern Plastics is the authoritative source of plastics information.
It is alive with opportunity for advertisers, readers, technicians, engineers.
It is a solid, aggressive institution.

That's why Modern Plastics readers—the kind that constantly need plastics information—stay interested.

That's why, according to the figures, they have given Modern Plastics a vote of confidence.

MODERN PLASTICS

"The Meeting Place and Market Place of Plastic Minds"

ABC MEMBER
AUDIT BUREAU
OF CIRCULATIONS

A BRESKIN PUBLICATION • PUBLISHED BY MODERN PLASTICS, INC.
122 EAST 42nd STREET, NEW YORK 17, N. Y.
Chicago • Cleveland • Los Angeles

DREVER

VERTICAL STRIP ANNEALING FURNACES

Drever Vertical Strip Furnaces. The furnace on the left handles three 8" strips up to five 5" strips, in gauges from .005" to .050" of non-ferrous materials. The new furnace on the right accommodates seven 5" strips up to three 12" strips. Note the bright, shiny finish of the stock coming off the recoiler ready for shipment.

Greatly INCREASE PRODUCTION IMPROVE QUALITY

Versatility and Flexibility of Production—Ferrous and Non-ferrous strip annealed in wide range of gauges . . . Minimum cycle adjustments . . . Rush and trial orders processed quickly . . . Single or multiple strips . . . Capacity from pounds to tons per hour.

High Quality Bright or Open Anneal—Absolutely clean and uniform anneal . . . Previous degreasing usually unnecessary, however degreasing and cleaning can be part of the line . . . Design features eliminate scratching, marking, gouging, abrading and other surface defects.

Minimum Floor and Storage Space—Vertical design greatly reduces area of furnace . . . Continuous production eliminates investment in stored materials and storage space.

Economical, Efficient Operation—Automatic temperature and line control reduces operating labor costs. The compact design of the furnaces, including entry and exit seals, effects a decided fuel savings and minimizes the amount of atmosphere gas consumed. Together the two furnaces illustrated use only 250 to 300 CFH of atmosphere gas. The ideal annealing atmosphere used is supplied by the DREVER AMMONIA DISSOCIATOR.

The Drever Engineering Staff will be pleased to discuss with you the inherent advantages of these and other furnaces as they may apply to your specific requirements.

EXPERIENCE POINTS TO ➧ THE DREVER CO.

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Helps make machines produce more at lower cost

SEVENTEEN YEARS AGO

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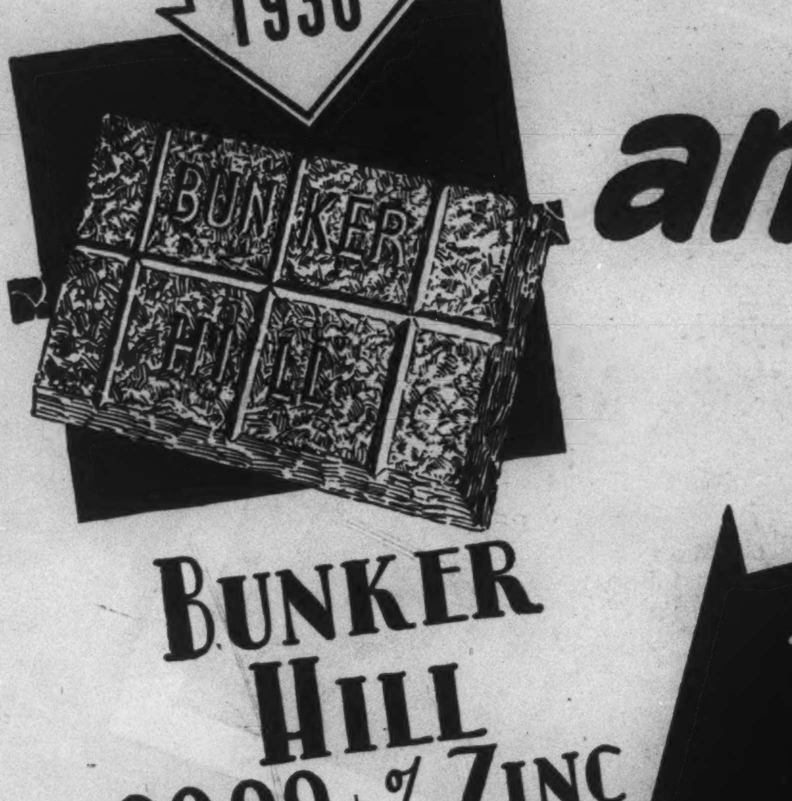

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The Remarkable New Die Casting Metal

Every die caster who has longed for a better zinc to gain additional markets at no extra cost now has that opportunity pounding at his door.

Bunker Hill Zinc will make die castings that cut "creep" to the minimum and will not "hot short" in the making. Add to this the extra advantages of increased hardness, tensile strength, ductility and impact resistance and you'll realize there's no better die casting zinc today.

Bunker Hill's 99.99+% Purity varies less than 1/100th of 1% (month in and month out) and actually costs less to use than lower grades. Be sure it's "Bunker Hill," that's all.

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Sales Office—250 Park Ave., New York
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...DIE CASTERS CONSUME OVER 150,000 TONS OF HIGH-PURITY ZINC ANNUALLY.

..."FOUR-NINES" METAL IS STANDARD FOR ALL ZINC ALLOY DIE CASTINGS.

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victor equipment company

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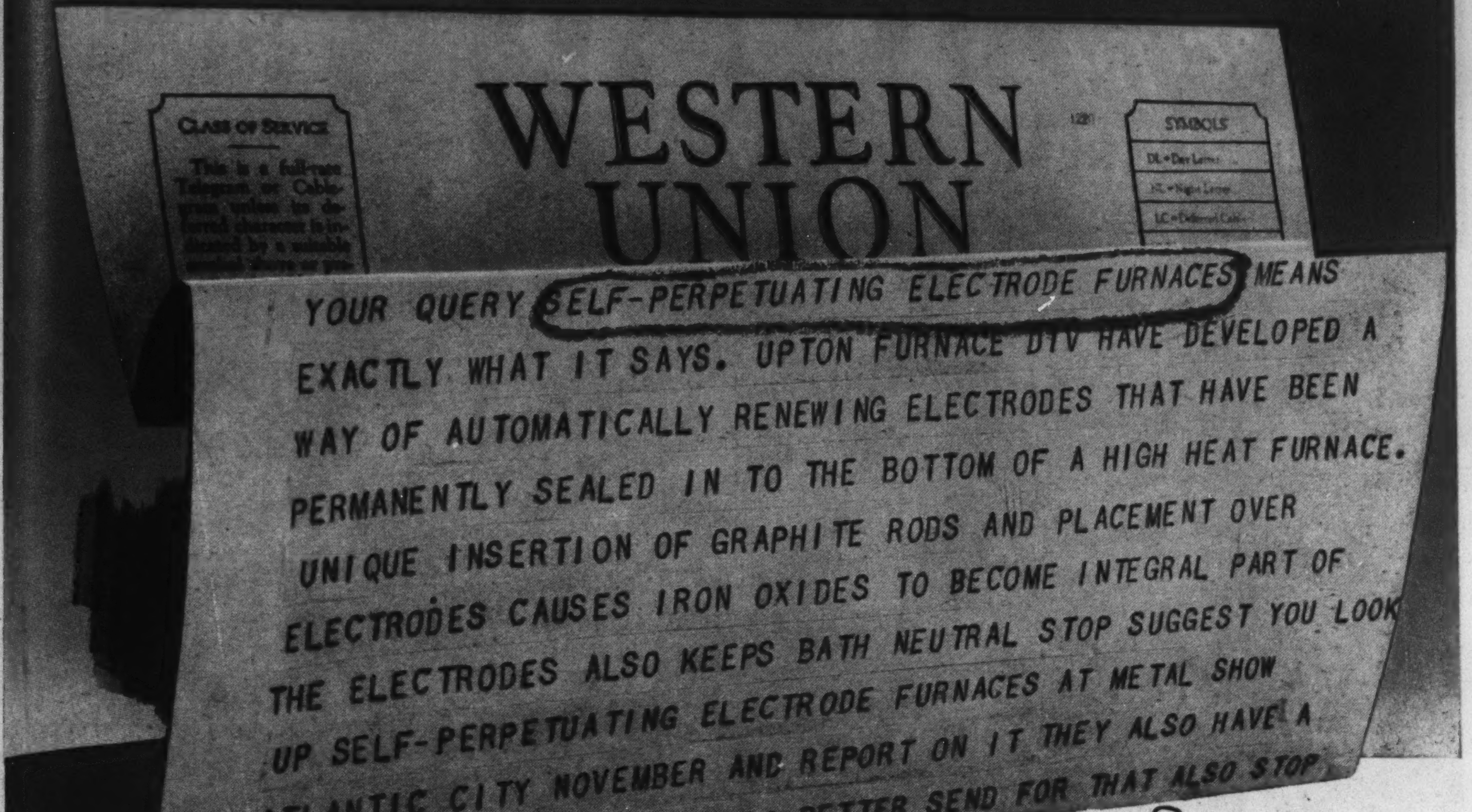

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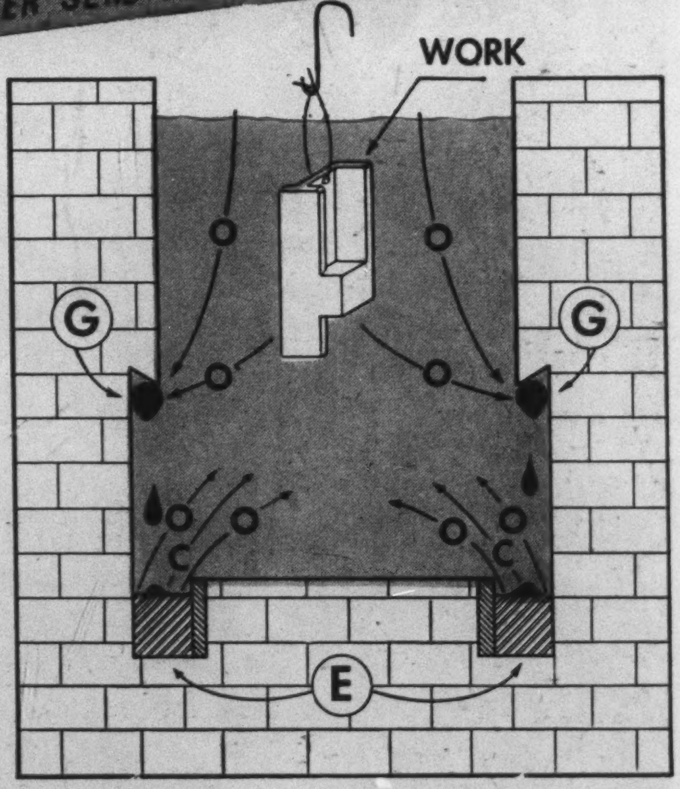
SYMBOLS

DL = Day Letter

NL = Night Letter

LC = Deferred Cable

YOUR QUERY SELF-PERPETUATING ELECTRODE FURNACES MEANS EXACTLY WHAT IT SAYS. UPTON FURNACE DIV HAVE DEVELOPED A WAY OF AUTOMATICALLY RENEWING ELECTRODES THAT HAVE BEEN PERMANENTLY SEALED IN TO THE BOTTOM OF A HIGH HEAT FURNACE. UNIQUE INSERTION OF GRAPHITE RODS AND PLACEMENT OVER ELECTRODES CAUSES IRON OXIDES TO BECOME INTEGRAL PART OF THE ELECTRODES ALSO KEEPS BATH NEUTRAL STOP SUGGEST YOU LOOK UP SELF-PERPETUATING ELECTRODE FURNACES AT METAL SHOW ATLANTIC CITY NOVEMBER AND REPORT ON IT THEY ALSO HAVE A BULLETIN THAT DESCRIBES SO BETTER SEND FOR THAT ALSO STOP



O OXIDE
C CARBON
E ELECTRODE
G GRAPHITE ROD

Oxides form in the bath, from contact with the atmosphere at the surface, from the work, and from absorption of oxygen from electrodes.

1. Electrodes give up oxygen, waste away.
2. Oxides circulating through bath contact graphite rod.
3. Oxides are reduced to metallic state in contact with graphite rod.
4. Increased carbon content reduces melting point of oxide.

Oxide droplets form, fall on electrode. Droplets begin giving up carbon, harden on electrodes, become integral part of electrode.

Ask for complete information on this process and its use in your heat treating.

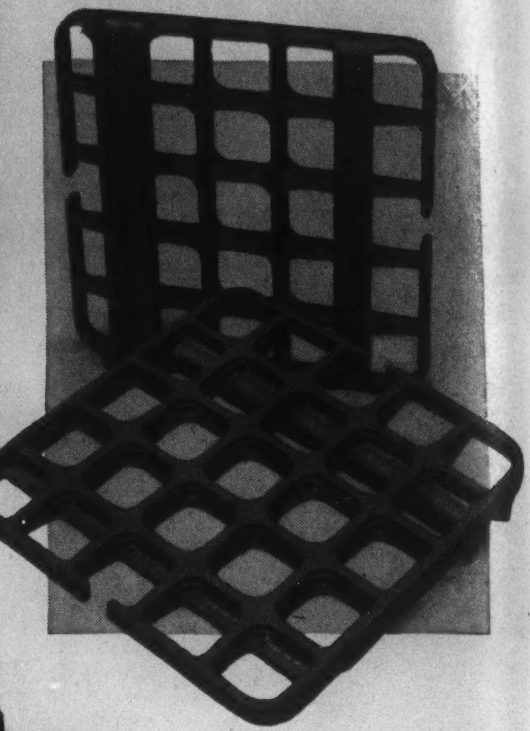
Upton ELECTRIC FURNACE DIV.

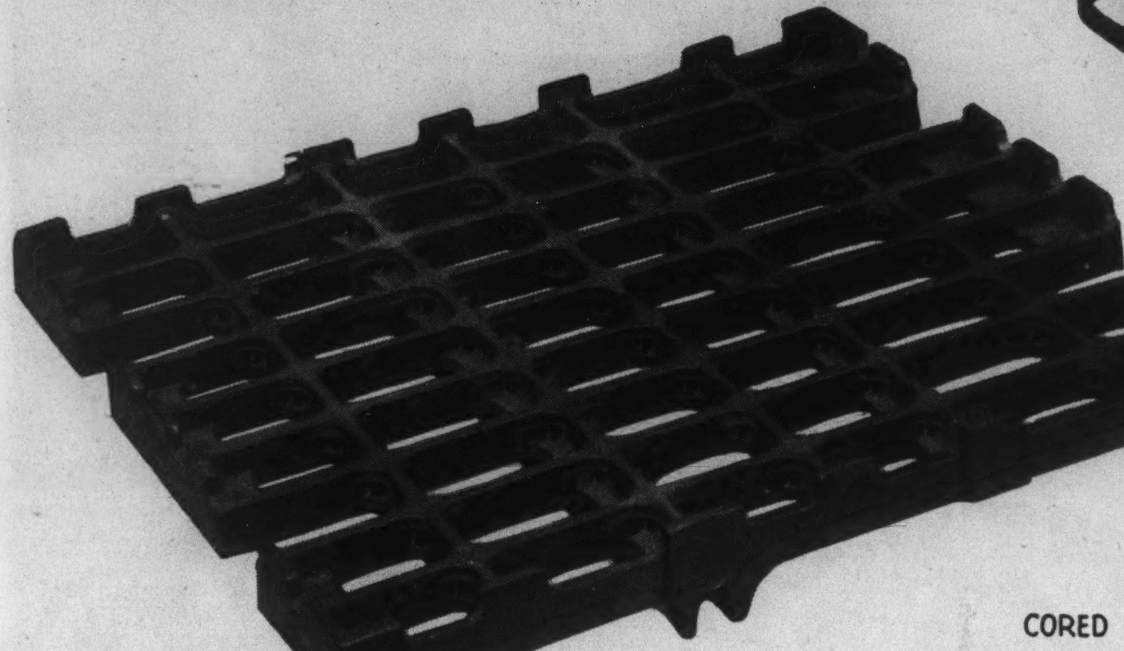
7425 MELVILLE AT GREEN • DETROIT 17, MICHIGAN

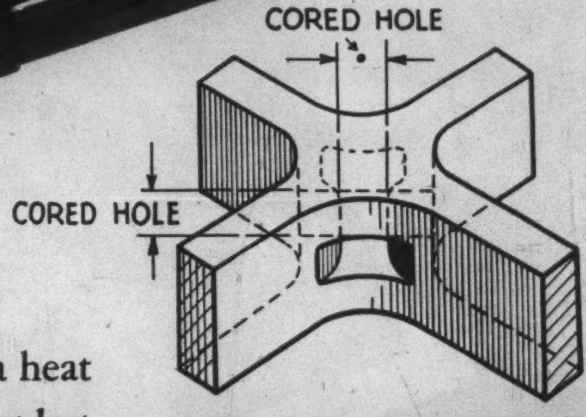
FOR MAXIMUM RIGIDITY AND FREEDOM FROM DISTORTION

Specify **MISCO**

HEAT RESISTING ALLOY TRAYS







One of the simplest ways of conveying material through a heat treating furnace is by means of the pusher tray. The simplest kind of pusher tray is the one-piece grid type illustrated above. The basic design is light, efficient and strong.

Add the Misco principle of grid-bar design and here is the strongest, most rugged tray construction yet devised. Users are enthusiastic and almost wish they could use more. But replacements are very rarely needed because Misco trays last so long.

THE MISCO PRINCIPLE OF GRID BAR DESIGN

Grid intersections are cored horizontally and diagonally through the neutral axis. Metal thus removed from regions of low stress is added to areas of high stress, where it increases load capacity, reduces distortion, and gives much longer life. U.S. PAT. 2242554.

SPECIFY MISCO HEAT RESISTING ALLOYS
CAST • ROLLED • FABRICATED
For all Heat Treating Equipment

Furnace Parts • Roller Rails • Roller Hearths • Conveyor Rolls • Trays • Retorts Chain • Muffles • Walking Beam Conveyors • Carburizing and Annealing Boxes Dipping Baskets • Cyanide and Lead Pots • Thermocouple Protection Tubes • Pickling Equipment • Centrifugal Castings • Miscellaneous Castings and Rolled Bars • Sheets, Plates, Tubes and Welding Rod for use at high temperature or under corrosive conditions.

ALLOY CASTING DIVISION

Michigan Steel Casting Company

MISCO
Heat and Corrosion Resistant Alloys

One of the World's Pioneer Producers of Heat and Corrosion Resisting Alloys

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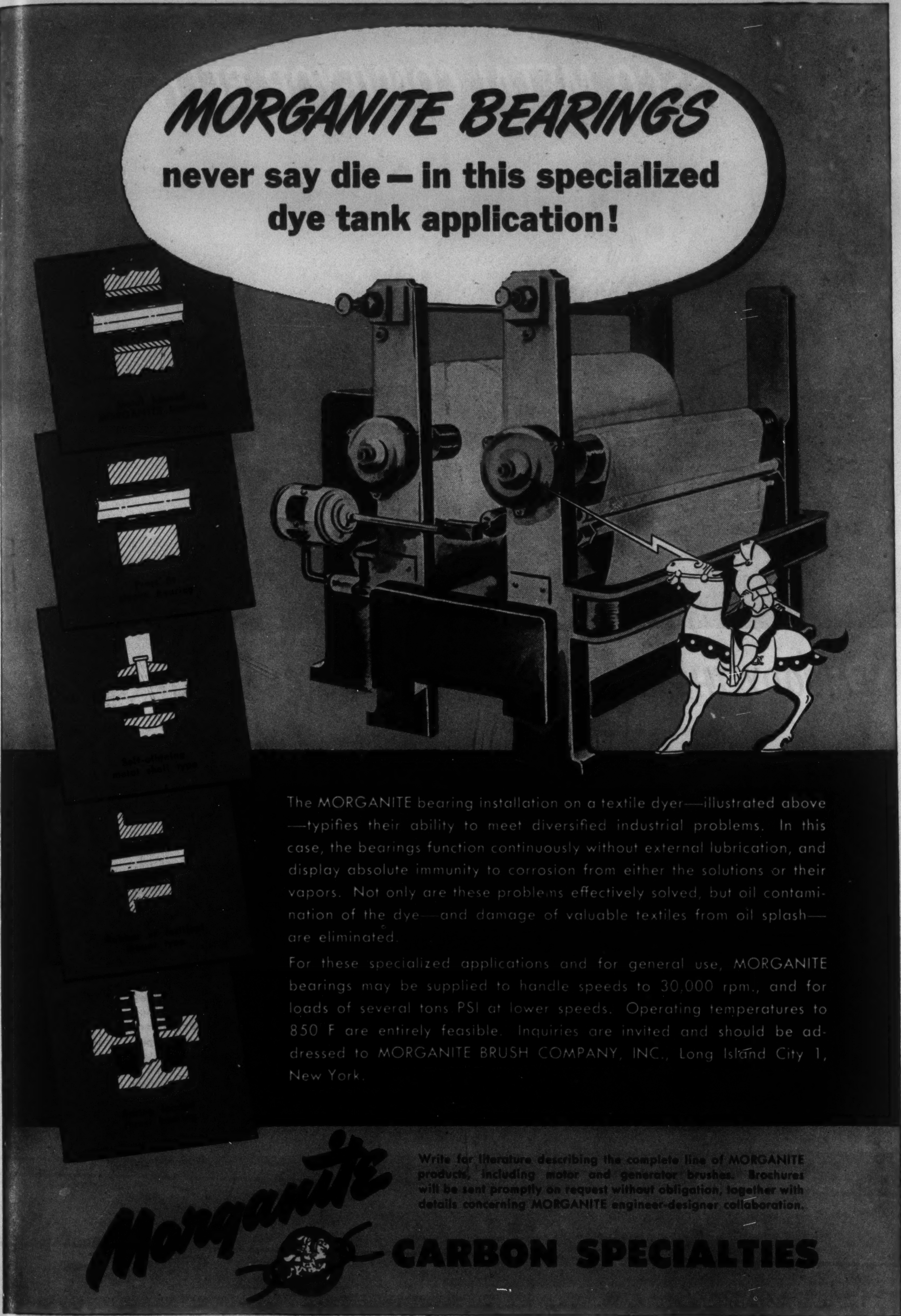


MORGANITE BEARINGS

never say die — in this specialized dye tank application!

The MORGANITE bearing installation on a textile dyer—illustrated above—typifies their ability to meet diversified industrial problems. In this case, the bearings function continuously without external lubrication, and display absolute immunity to corrosion from either the solutions or their vapors. Not only are these problems effectively solved, but oil contamination of the dye—and damage of valuable textiles from oil splash—are eliminated.

For these specialized applications and for general use, MORGANITE bearings may be supplied to handle speeds to 30,000 rpm., and for loads of several tons PSI at lower speeds. Operating temperatures to 850 F are entirely feasible. Inquiries are invited and should be addressed to MORGANITE BRUSH COMPANY, INC., Long Island City 1, New York.

Write for literature describing the complete line of MORGANITE products, including motor and generator brushes. Brochures will be sent promptly on request without obligation, together with details concerning MORGANITE engineer-designer collaboration.

Morganite CARBON SPECIALTIES

WISSCO METAL CONVEYOR BELTS

EMBODY THESE 5 COST-CUTTING CHARACTERISTICS

1 **EXTREME FLEXIBILITY**—Wissco Belts will operate over small diameter pulleys, insuring economy of design.

2 **OPEN WEAVE CONSTRUCTION**—Permitting free air circulation; free drainage.

3 **SIMPLICITY OF DESIGN**—Easily made endless. Readily repaired in case of accidental damage.

4 **ADAPTABILITY**—Built to withstand corrosion, abrasion, brazing temperatures.

5 **MINIMUM OPERATING COSTS**—Greatest load carrying capacity per unit of weight and low thermal capacity means fuel economy.

Send for our profusely illustrated catalog showing types and advantages of numerous conveyor belt constructions.

Wissco Metal Conveyor Belts Are Being Used In

- Annealing Ovens
- Baking Ovens
- Brazing Furnaces
- Chemical Processing
- Decorating Glass
- Ceramic Products
- Canning
- Dehydrating Food
- Degreasing
- Frozen Foods
- Hardening Furnaces
- Infra-Red Drying
- Reclaiming Tin, etc.

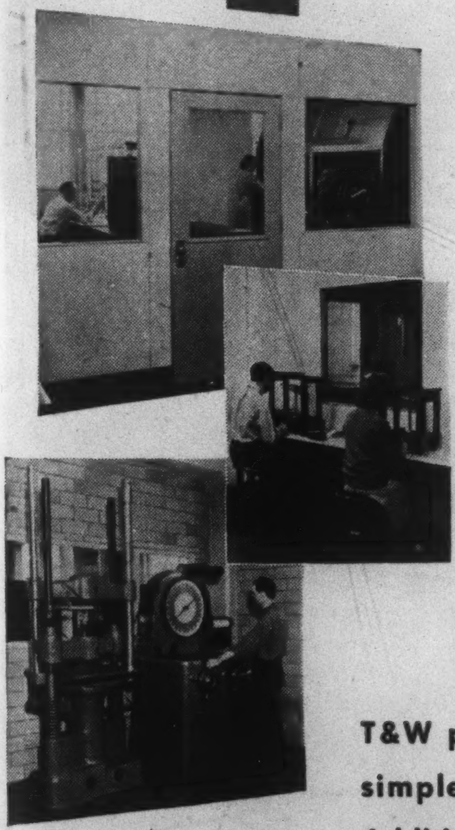
WISSCO METAL CONVEYOR BELTS

A PRODUCT OF WICKWIRE SPENCER STEEL DIVISION OF THE COLORADO FUEL AND IRON CORPORATION

CF&I

Sales Office and Plant—52 Sterling St., Clinton, Mass. *General Sales Office*—361 Delaware Ave., Buffalo 2, N.Y.
District Offices: Boston, Chicago, Denver, New York. The California Wire Cloth Corporation, Oakland 6, Calif.

T&W FORGINGS USUALLY COST LESS AT THE *Point of Assembly*



Partial View of Chemical Laboratory

Determining Carbon Content of Steel

Tension and Compression Testing Machine

Any difference in the price of a specific lot of forgings as between two or more sources of supply may result, as it often does, in a wider spread in final cost at the point of assembly with the forgings that were *lowest in price* at the point of delivery being the *highest in cost at the point of assembly.*

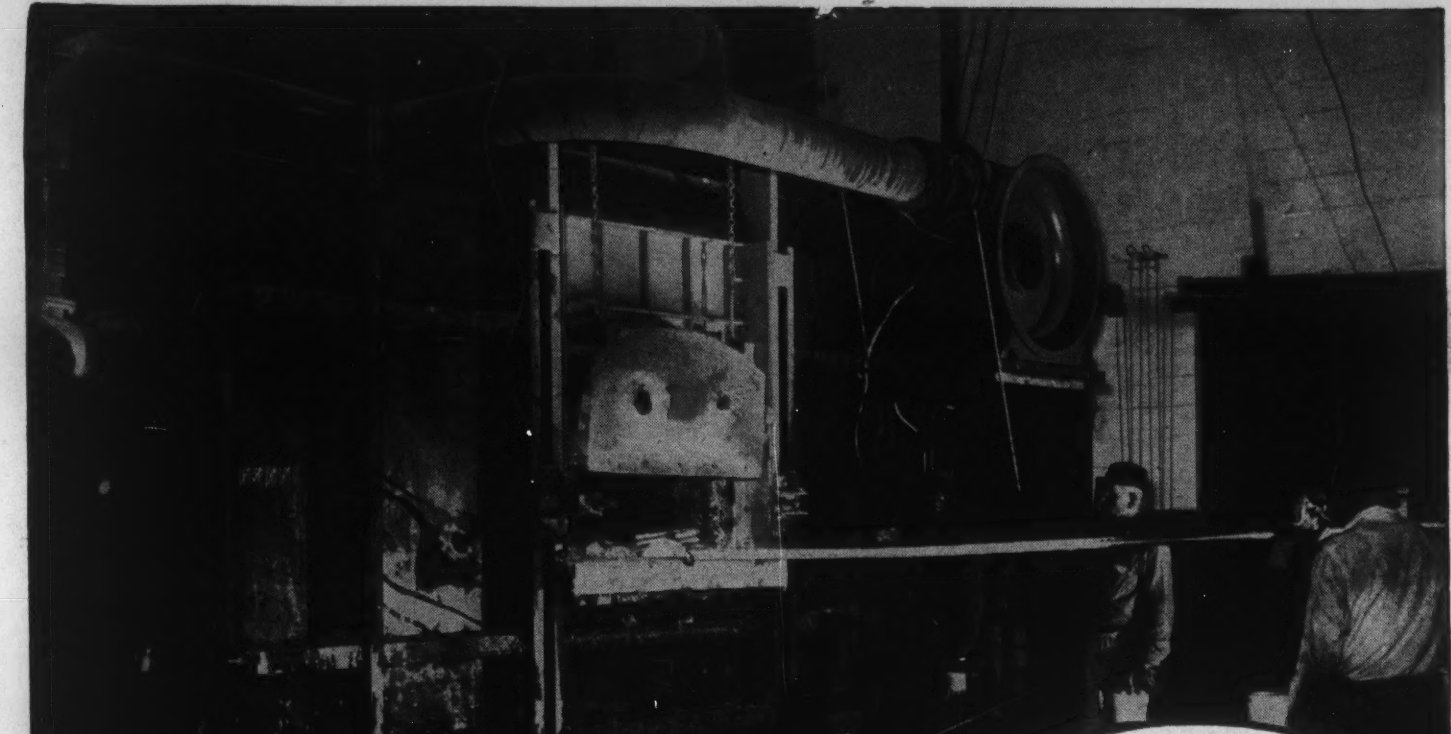
Ask a T&W Forging Engineer for supporting evidence that T&W forgings usually cost less at the point of assembly.

T&W produces drop or upset forgings from one ounce to 500 lbs. each; simple or complex designs from carbon, alloy, and stainless steels. Additional T&W services include heat treating, metallurgical control of quality at every stage of production, chemical analyses of steel, physical testing in a completely equipped laboratory, and magnetic inspection.

TRANSUE & WILLIAMS

STEEL FORGING CORPORATION • ALLIANCE, OHIO

SALES OFFICES: NEW YORK • PHILADELPHIA • CHICAGO • INDIANAPOLIS • DETROIT • CLEVELAND



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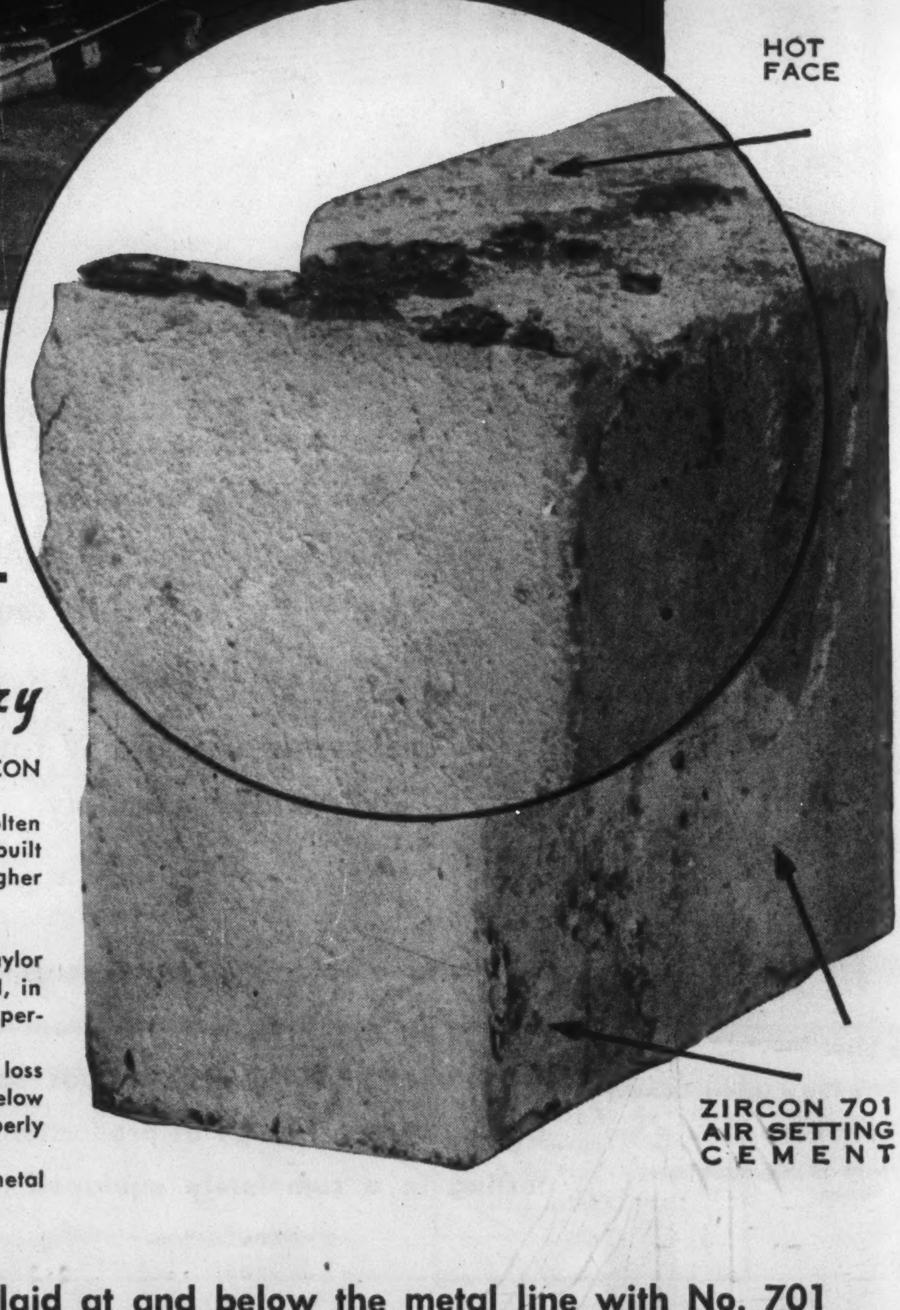


Taylor ZIRCON BRICK and #701 CEMENT

for the Aluminum Industry

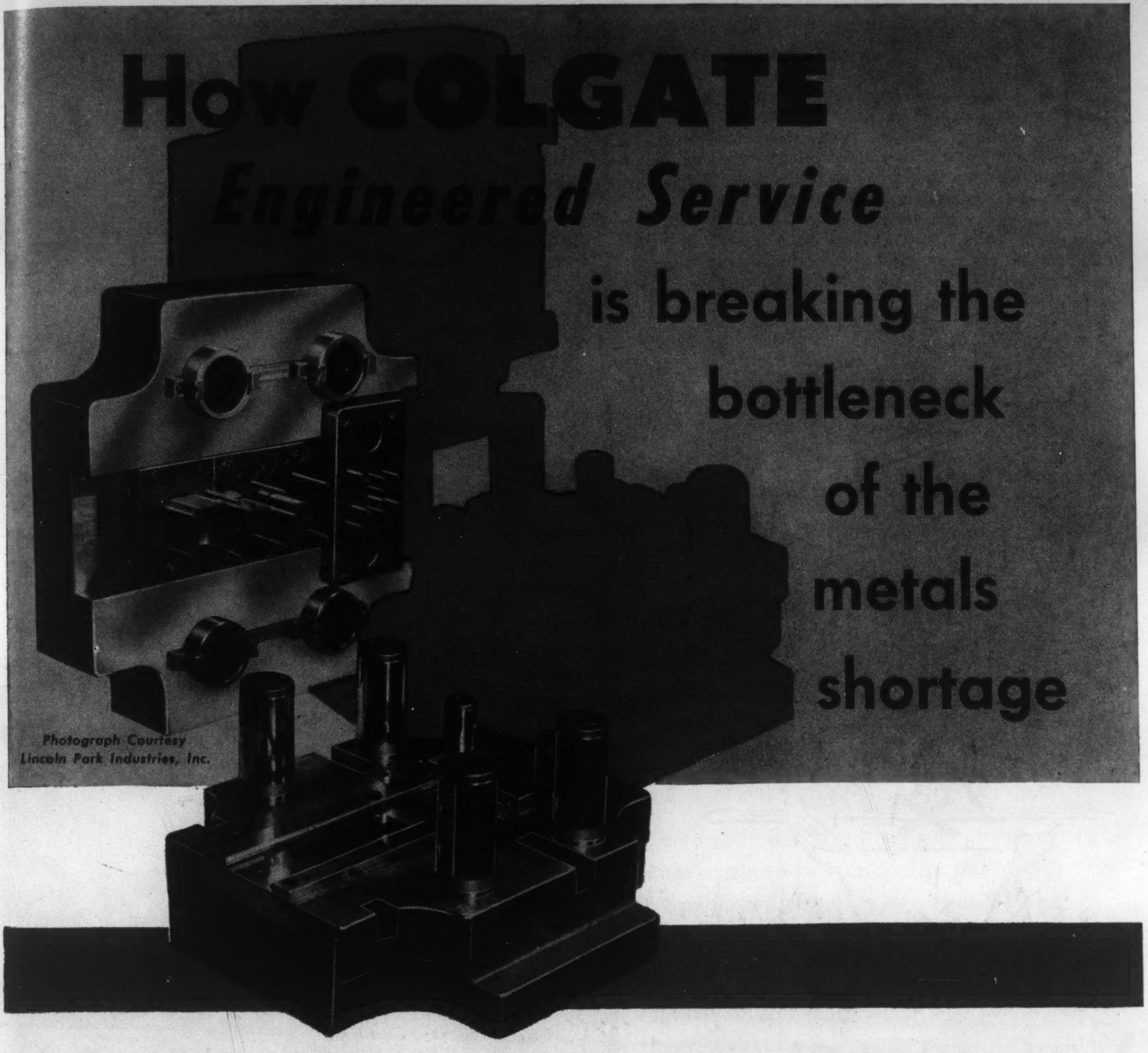
Casting superintendents and plant metallurgists prefer Taylor ZIRCON brick side walls and hearths for these reasons:

- Taylor ZIRCON refractories are not readily "wet" by molten aluminum and the common alloys. Open-hearth furnaces built with Taylor ZIRCON brick and No. 701 Cement produce a higher yield of clean metal.
- Danger of silicon pick-up is minimized.
- Increased production as open-hearth furnaces lined with Taylor ZIRCON brick can be cleaned or scraped, either h-o-t or cold, in ½ to ⅓ the time required to clean the ordinary fire clay, super-duty or high alumina brick lined furnace.
- Metal composition can be changed without allowing for the loss of 3 or 4 wash heats. No metal will be trapped within or below the working face of the Taylor ZIRCON hearth, in a properly designed furnace.
- Lower hearth and side wall cost per ton of sound, clean metal cast.

PROTECT joints by bonding all bricks laid at and below the metal line with No. 701 ZIRCON Air-Setting Cement. Use No. 701 for laying Fire Clay, Super-Duty, High Alumina or Taylor ZIRCON bricks with thin, tight, trowelled joints.

CHAS. TAYLOR SONS Co.

MANUFACTURERS OF REFRACTORIES • CINCINNATI • OHIO • U. S. A.



How COLGATE *Engineered Service* is breaking the bottleneck of the metals shortage

Photograph Courtesy
Lincoln Park Industries, Inc.

MANY MANUFACTURERS have asked us whether it is possible to make an assembly or part in another metal *temporarily,* and still use the fabricating and stamping tools, when the time comes, for the preferred metal.

It's not only frequently *possible*... Colgate is *doing it.* By designing double purpose dies so that they may be used, during this interim period with a second-choice material, and later converted, Colgate is breaking the bottleneck of the metals shortage.

Dies engineered to serve a double purpose is just one example of Colgate *Engineered Service* in sheet metal fabricating and stamping of aluminum, magnesium, stainless steel and many other light metals.

If your product is ordinarily made of steel (let's say), perhaps some other material could be used. Then, when steel becomes *available,* in many cases the tools can be converted, at reasonable cost, through Colgate's *Engineered Service.* Write for more information.

STAMPING • FORMING • DRAWING • WELDING • FINISHING • ASSEMBLING

COLGATE *Manufacturing Corporation*
AMITYVILLE, LONG ISLAND, NEW YORK
LIGHT METALS PRODUCTS

X Skilled craftsmen of the Orient forged the famous Damascus swords from about the tenth to the fifteenth centuries. Tradition relates that these famous swords were laboriously hammered at the forge until the metal resembled the color of the moon, when the blade was quenched by driving it into the side of a slave. Then, as now, each group of forging craftsmen jealously guarded a standard of quality. Differences in the quality of forgings were inevitable, and the differences were due then, as they are today, to pioneering, ingenuity and enterprise—to the irrepressible urge to excel in forging craftsmanship.

X The Vital Element in the Improvement of Metals by Forging is..MEN!

Differences in the quality of forgings as between two or more sources of supply are inevitable. Differences in tolerances are visible and measurable, but differences of vital importance are revealed only by microscopic or X-ray examination. Differences in the mechanical properties of forgings are the result of individualized applications of engineering principles and forging techniques, applications which differ in accordance with the difference in the skill and philosophy of executives, engineers, metallurgists and forging craftsmen. Fortified by 33 years' experience in forging intricate designs, and by specialized metallurgical and engineering skill thus acquired, Steel Improvement Forging Engineers and Metallurgists: (1) know the exact forging technique that should be utilized for developing fully the qualities, inherent in a specific grade of steel, that are required to meet the stresses occurring in a specific service condition; (2) advise and assist designers regarding the correct placement of parting lines and other design elements; and (3) adhere strictly to a policy of projecting a promise of quality and delivery only when such promise can be substantiated by fact or experience, or both. Consult a Steel Improvement Forging Engineer about the measure of quality in forgings you require.

Write for reference booklet titled "The Improvement of Metals by Forging", which has been prepared especially for executive engineers, designers and metallurgists.

DROP FORGINGS
THE STEEL IMPROVEMENT & FORGE CO.
956 East 64th Street CLEVELAND, OHIO
SALES OFFICES: NEW YORK • CHICAGO • MILWAUKEE • TULSA • LOS ANGELES

DROP, UPSET AND PRESS FORGINGS FROM A FEW OUNCES TO 500 LBS. OF ALL FORGEABLE METALS

MALLORY
ELECTRICAL CONTACT
DATA BOOK
MATERIALS • DESIGNS
AND APPLICATIONS
EVERYTHING YOU WANT TO KNOW
ABOUT ELECTRICAL CONTACTS

The First Book of Its Kind . . .

Competent, Complete!

A Summary of Contents

- Fundamentals of Electrical Contacts
- Selection of Contact Materials
- Contact Design, Assembly Methods and Maintenance
- The Automotive Battery Ignition Systems
- Contacts for Low Voltage Type Voltage and Current Regulators
- Contact Materials in Circuit Breakers
- Sliding Contacts
- Fundamentals of Electricity for Contact Applications
- Miscellaneous Tables — Engineering Data

Until recently there was very little published information on electrical contacts. What information existed was scattered in magazine articles and in two obscure books published abroad.

Now comes the first "encyclopedia" on the subject — a volume so comprehensive that it includes the latest there is to know about contact design, construction, application and materials . . . so completely up-to-date that it includes theories that have yet to be established, opinions that have yet to be proved. This is because the subject, even at this late date, has many controversial aspects.

Five years in the writing, the Mallory Contact Data Book belongs in every engineering library. Its combination of scientific facts, observations, first-hand experiences cannot be duplicated anywhere else. To recognized engineers writing on company letterhead, the book is free. To others, it is available at our printing cost — $2.50. *The Contact Data Book is still another example of Mallory's desire to provide helpful material for those who have a professional interest in the fields we serve.*

P. R. MALLORY & CO. Inc.
MALLORY ELECTRICAL
CONTACTS & CONTACT ASSEMBLIES

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Zinc Chromate Primer Spec. AN-TT-P-656	$1.20 per Gallon
Zinc Chromate Primer Spec. 52-P-18	1.00 per Gallon
Synthetic Primer for Ferrous Metals Spec. 3-171	.65 per Gallon
Lacquer Resistant Synthetic Primer Spec. 3-183	.65 per Gallon
Synthetic Refinishing Primer Spec. 3-172A	.65 per Gallon
PIGMENTED LACQUER	$ .50 per Gallon
Lustreless Lacquer Spec. 3-162	
(This price applies to all colors except Olive Drab)	
SPECIAL	$ .30 per Gallon
All Olive Drab Paints—Lacquers—Enamels	
(Minimum sale quantity 500 gallons)	
ACID PROOF BLACK PAINT	$ .16 per Gallon
Spec. 3-106-E	
(useful for many purposes)	
OLEORESINOUS PAINT SPEC. T-1279	
A Utility Maintenance Paint)	
Olive Drab, Loam	.30 per Gallon
All other colors	.49 per Gallon

PRICES ARE F. O. B. LOCATION

Although this material has been previously offered to priority claimants, 10 per cent of the merchandise has been reserved to fulfill any further needs of priority claimants including VETERANS OF WORLD WAR II who are invited to contact the Regional Office serving their area.

EXPORTERS: The War Assets Administration solicits your inquiries. Communicate with your foreign clients promptly.

Large quantities of good quality protective coatings, now declared surplus, offer you an unusual opportunity to obtain items manufactured to exacting Government specifications. While some types and kinds of protective coatings are in short supply commercially (due to lack of raw materials) . . . there are paint products of all types now in inventory which will be suitable for your present needs at *low prices.*

Your nearest War Assets Regional Office can give you complete information regarding prices, locations, quantities, types and colors available. Special inter-regional service in each Regional Office will provide you with similar information from other Regions.

In addition to paints and enamels for general use, available stocks include many *special* purpose finishes. ACT NOW!

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GOVERNMENT
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563-3

VANCORAM
BRAND

Products for the Iron and Steel Industries

PRODUCT	TYPICAL COMPOSITION	APPLICATIONS
ALSIFER	Aluminum.......20% Silicon..........40% Iron............40%	Used principally as a steel deoxidizer and for grain size control.
FERRO CHROMIUM High Carbon Grade	Chromium....66-70% Carbon.........4-6%	For wrought constructional steels and steel and iron castings.
Iron Foundry Grade	Chromium....62-66% Carbon.........4-6% Silicon.........6-9%	For alloyed cast irons. Readily soluble as a ladle addition at the lower temperatures of cast iron.
Low Carbon Grades	Chromium....67-72% Carbon...06%, .10%, .15%, .20%, .50%, 1.00% and 2.00% max.	For low carbon chromium steels, especially those with high chromium content, such as stainless and heat-resistant types.
FERRO SILICON 25-30% Grade	Silicon.......25-30%	Deoxidizer for open hearth steels; also for high silicon, corrosion-resistant iron castings.
50% Grade	Silicon.......47-52%	Used as a deoxidizer and for the addition of silicon to high silicon steels, for springs, electrical sheets, etc. Pulverized form used as ladle addition to cast irons for silicon content and graphitization control.
75% Grade	Silicon.......74-79%	For high content silicon steels, such as spring steels, sheets and forgings of high magnetic qualities for electrical apparatus.
High Silicon Grades 80-85% 85-90% 90-95%	 Silicon.....80-84.9% Silicon.....85-89.9% Silicon.......90-95%	For high content silicon steels where small ladle additions are used for required silicon content. Also for manufacture of hydrogen by reaction with caustic soda and production of magnesium by the Pidgeon process.
FERRO TITANIUM High Carbon Grade	Titanium.....15-18% Carbon.........6-8%	Final ladle addition to control "rimming" action and to clean effervescing steel. Final deoxidizer and scavenger for steel castings and fully killed ingot steels.
Medium Carbon Grade	Titanium.....17-21% Carbon......3-4.50%	Often preferred to the High Carbon Grade as a final ladle addition to very low carbon rimming or effervescing steels.
Low Carbon Grades 20-25% Ti Grade	Titanium.....20-25% Carbon...max. 0.10% Silicon......max. 4% Aluminum max. 3.50%	Carbide stabilizer in high chromium corrosion resistant steels of extremely low aluminum content. Deoxidizer for some casting and forging steels.
40% Ti Grade	Titanium.....38-43% Carbon...max. 0.10% Silicon......max. 4% Aluminum...max. 8%	Carbide stabilizer in high chromium corrosion-resistant steels, where smaller ladle additions are desired and extremely low aluminum content is not essential.
VANADIUM METAL 90% Grade	Vanadium....91.15% Aluminum.....3.87% Silicon........0.50% Carbon........0.17%	For special iron-free (nonferrous) or low iron alloys or low impurity ferrous alloys.
95% Grade	Vanadium....95.18% Aluminum.....2.00% Silicon........0.27% Carbon........0.40%	Principally for research on the properties of pure alloys.
FERRO VANADIUM Grade "A" (Open Hearth)	Vanadium....35-40% Silicon.....max. 12% Carbon...max. 3.50%	For low percentage vanadium content of rolled, forged or cast constructional steels. Also used in vanadium cast irons.
Grade "B" (Crucible)	Vanadium....35-45% Silicon...max. 3.50% Carbon...max. 0.50%	For tool steels and special steels containing high percentages of vanadium, in which required limits for carbon and silicon are narrow.
Grade "C" (Primos)	Vanadium....35-45% Silicon...max. 1.25% Carbon...max. 0.20%	For tool steels and special steels requiring high percentages of vanadium and exceptionally low carbon and silicon content.
Special Grades	Vanadium....50-55% 60-65% 70-80% Silicon..........Low Carbon..........Low	For special applications and uses requiring large vanadium additions.
VANADIUM PENTOXIDE Technical Grade Fused Form	V_2O_5.....90%	A source of vanadium in basic electric furnace steels. A base for numerous chemical compounds.
Technical Grade Air Dried Form	V_2O_5........83-85%	A base for preparation of numerous chemical compounds, such as catalysts, etc.
GRAINAL ALLOYS Vanadium Grainal No. 1	Vanadium....25.00% Aluminum....10.00% Titanium.....15.00% Boron..........0.20%	Practical and economical intensifiers for controlling and increasing the capacity of steels to harden, and for improving other important engineering and physical properties.
Vanadium Grainal No. 6	Vanadium....13.00% Aluminum....12.00% Titanium.....20.00% Boron..........0.20%	See above.
Grainal No. 79	Aluminum....13.00% Titanium.....20.00% Zirconium.....4.00% Manganese....8.00% Boron..........0.50% Silicon........5.00%	See above.
GRAPHIDOX No. 4	Silicon.......42-46% Titanium......9-11% Calcium........5-7%	New alloy for the graphitization of iron; ladle treatment insures iron with normal graphite, free from dendritic structure; reduces chill; efficient inoculant in the production of high strength irons.
V-FOUNDRY ALLOYS V-5 Grade	Chromium....38-42% Silicon........17-19% Manganese....8-11%	Used in cast irons as a ladle addition. Reduces chill, promotes uniformity of structure, increases strength and hardness.
V-7 Grade	Chromium....28-32% Silicon........15-21% Manganese...14-16%	See above.
BRIQUETTES Ferro Chromium	Hexagonal in shape. Weigh approximately 3⅜ lb. and contain 2 lb. of chromium.	A practical and convenient form for adding ferro-alloys to the cupola.
Ferro Silicon	Two sizes available, both cylindrical in form, one containing 1 lb. of silicon; the other 2 lb. of silicon.	See above.

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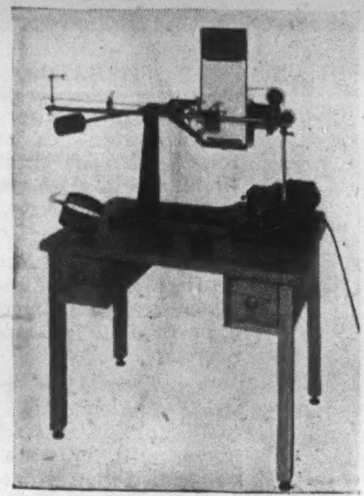
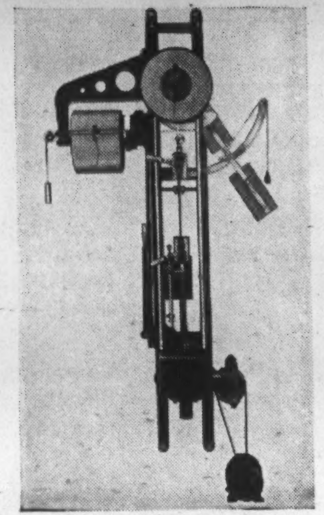
420 LEXINGTON AVENUE, NEW YORK 17, N. Y. · DETROIT · CHICAGO · CLEVELAND · PITTSBURGH

LABORATORY PRECISION *Plus* PRODUCTION-TESTING STAMINA

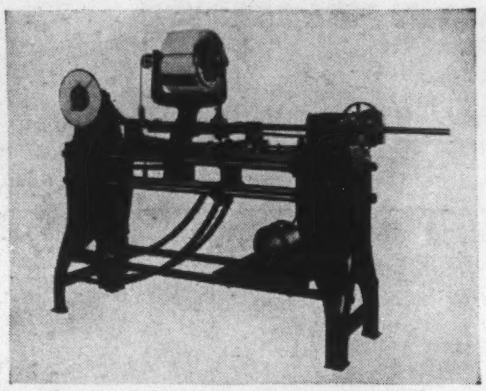


Incline-plane Tester for finest vacuum tube and grid wires. Capacity 0 to 2,000 grams.



Model J, available in various capacities from 0 to 1,000 lbs. tensile.

Model Q heavy duty production-type tester, with capacity up to 2,000 lbs.



*SCOTT TESTERS perform many tests on WIRE and STRIP.

From finest filament to 2,000 lbs. tensile, *Scott Testers provide for practically every needed physical test: tensile, hysteresis, twist, flexing, adhesion, compression-cutting of rubber covering, etc., producing results as "picturized" charts, easy to read and handy for reference. Combined with their high precision is extreme ruggedness—these machines stand up under production testing year after year.

Descriptive Literature Upon Request

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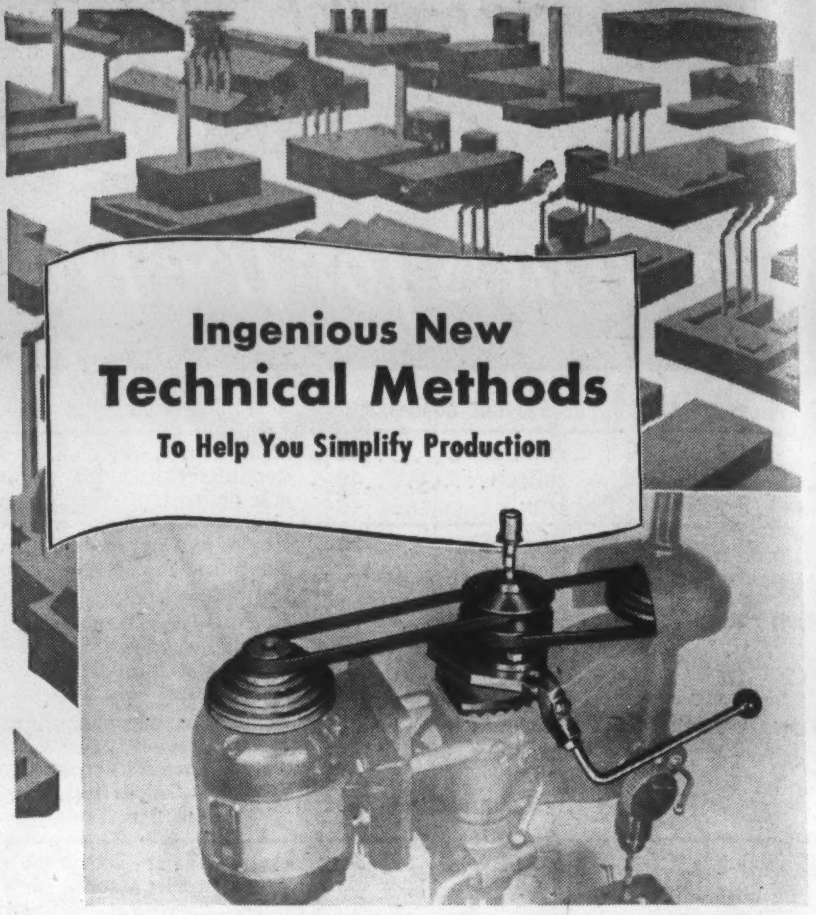
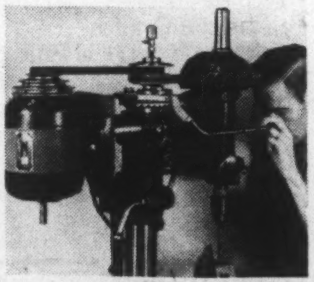


Ingenious New Technical Methods

To Help You Simplify Production

Variable Speed Drive Attachment Offers Instant Speed Control for Drill Press Work!

Now you can adjust drill press speeds from high to low —or any intermediate speed —as easily as shifting gears in your car! The Era Variable Speed Drive Attachment enables the operator to provide the correct speed for large or small drills by merely moving a lever. This saving in time results in greater work volume, better work, and lower production cost.



Era Variable Speed Drive

The Era Attachment fits all popular makes of drill presses, and is easily installed without the necessity of drilling holes or changing present equipment.

To also help save time on the job, many plant owners make chewing gum available to workers. Chewing gum seems to make work go easier, time go faster. Wrigley's Spearmint Gum may be used even when both hands are busy, eliminating work interruptions, and thus promoting greater safety for the operator.

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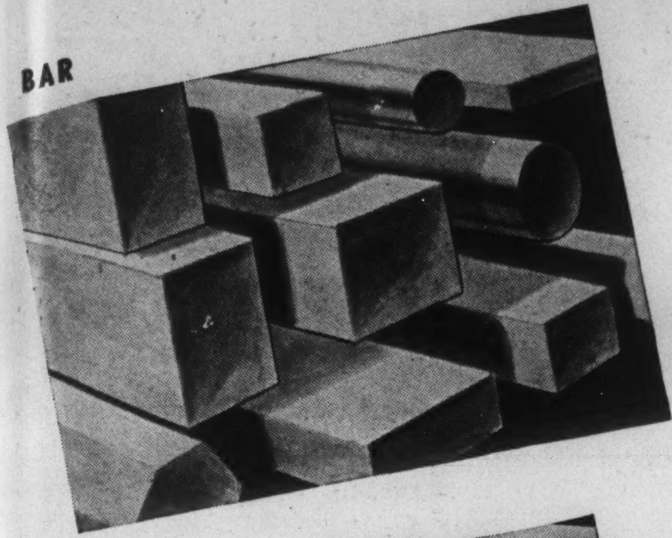
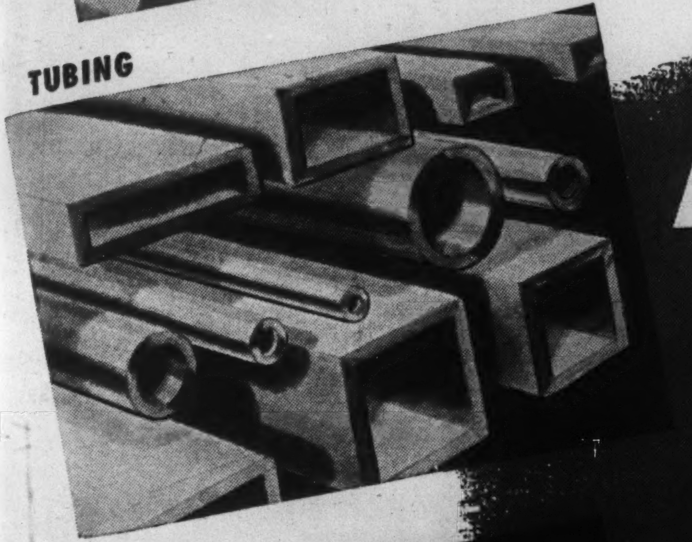
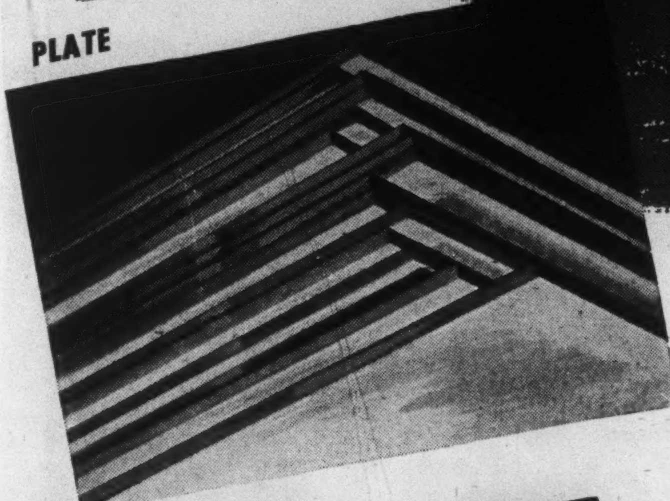


TUBING



PLATE



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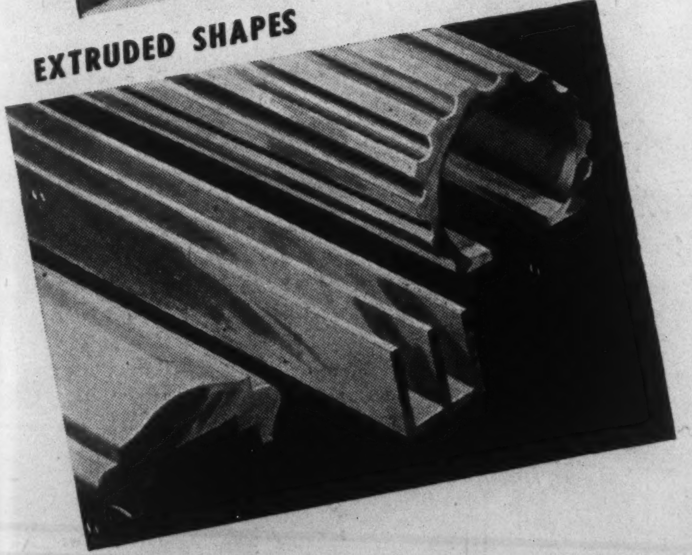

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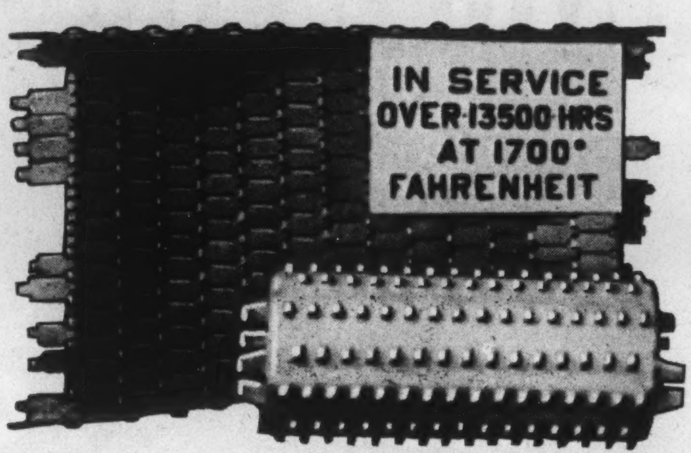
PYRASTEEL

PYRASTEEL sprocket and section of belt conveyor



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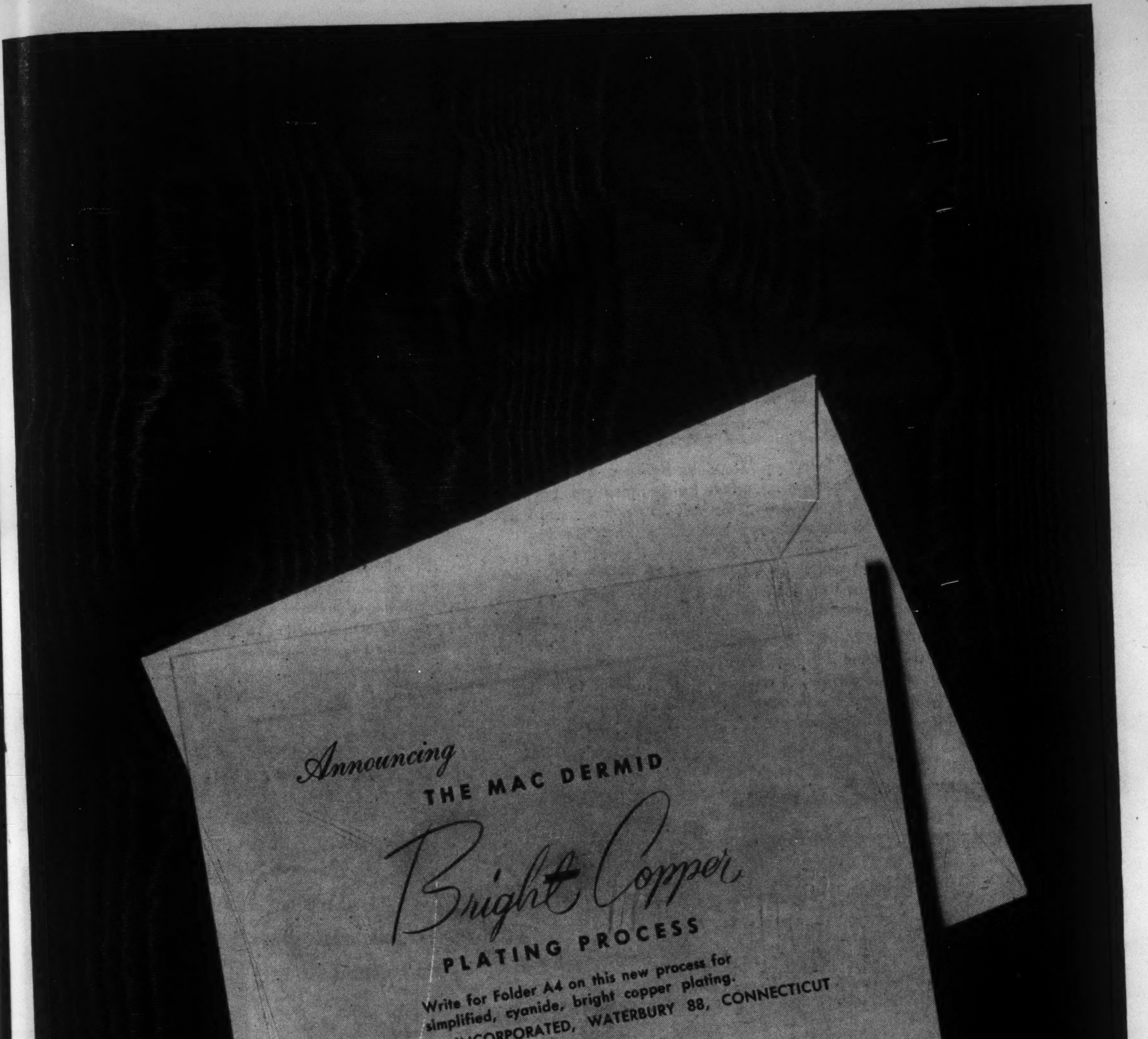
UNITED STATES STEEL



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YOU CAN SAVE METAL, INCREASE PRODUCTION, DECREASE MAINTENANCE AND IMPROVE PRODUCTS BY FORMING WITH

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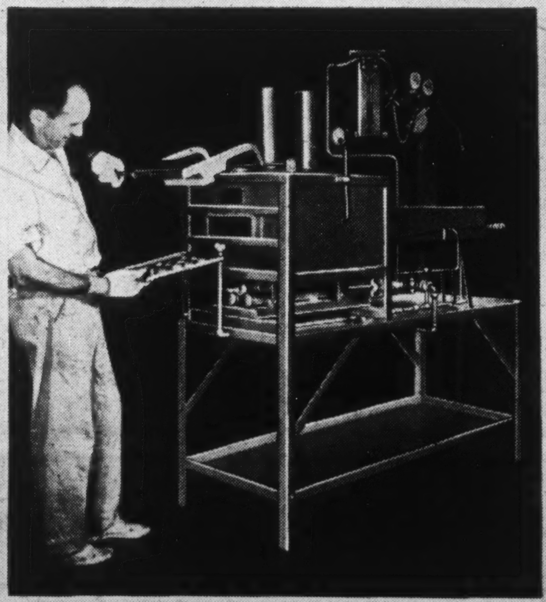

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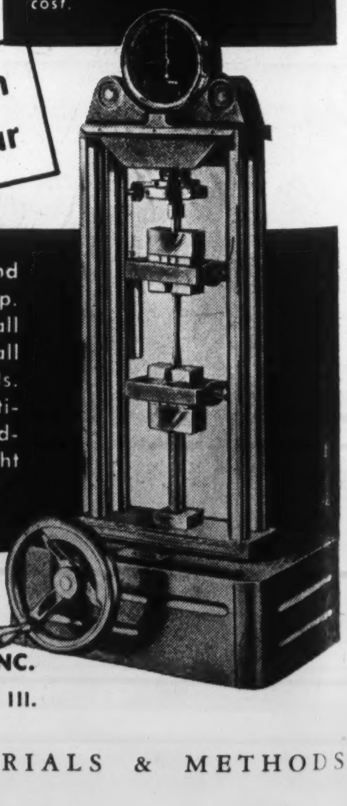

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DIE-LESS DUPLICATING

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For production line testing or critical laboratory analysis. Fits into "tight" spots or complicated setups with ease.

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Thousands in daily use by aircraft plants, U.S. Navy, industrial concerns. Render correct reading in matter of seconds. Not injured by overload.

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Dillon Dynamometer measures only 8¼"x 6¼"x3" and weighs 8 lbs. 4 oz. Fits into practically any mechanical setup where tensile strength must be measured or tension determined. Capacities up to 20,000 lbs. Low cost—immediate delivery.

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New air-set refractory cement stays workable, ready to use

It's Armstrong's ACASET

Armstrong's Acaset is a newly developed, all-purpose air-setting refractory cement. It provides practical workability, meets all essential engineering requirements, and saves you money four ways.

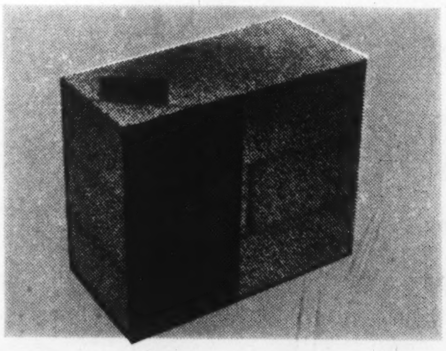
1. Masons' time is conserved. This cement pours readily. It doesn't require digging out or thinning. Its excellent water retention allows spreading well ahead of the bricklayer.
2. Since Acaset is an all-purpose cement—for bonding or facing fire brick or insulating brick—inventory stocks can be reduced.
3. Acaset Cement does not deteriorate in storage, so it can be purchased in economical quantities.
4. Acaset reduces maintenance costs of the furnaces in which it is used.

Acaset provides a tight permanent joint as effective as the brick itself and a strong bond that will not allow brick to become loose in the wall. This cement takes a strong set at room temperature and maintains its strength throughout its entire working range. The most exacting specification for an air-setting cement calls for a cold bonding strength of 200 pounds per sq. in. Acaset is three times that strong. It meets the specifications of the A. S. T. M., the American Refractories Institute, the Federal Government, and the U. S. Navy for a high heat duty mortar. Under heat Acaset will not soften or run out of the joints. It withstands abrasion, slagging, and spalling.

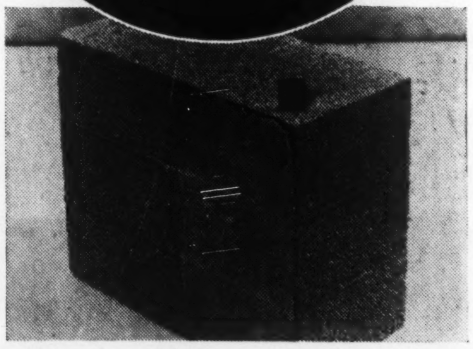
For full details of this remarkable new cement, write today to Armstrong Cork Co., Industrial Insulation Dept., 5512 Mulberry Street, Lancaster, Penna.

NEW. Armstrong's ACASET Cement pours freely even after months of storage, saving time and trouble for the bricklayer.

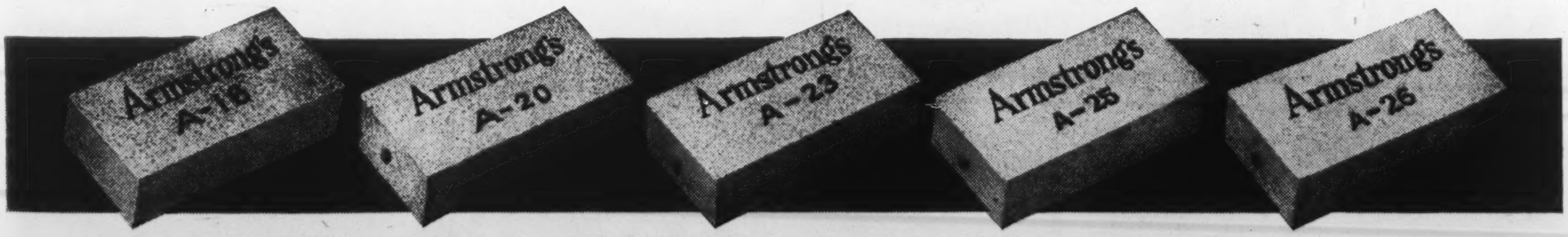
OLD. Many air-set cements tend to harden in the drum, must be dug out and remixed.



NEW. The low shrinkage of Armstrong's ACASET prevents tearing face of insulating fire brick.



OLD. Shrinkage of face coating of ordinary air-setting cement has torn face of insulating fire brick.



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HIGH TEMPERATURE ELECTRIC FURNACE

FOR ANNEALING, BRAZING, SINTERING

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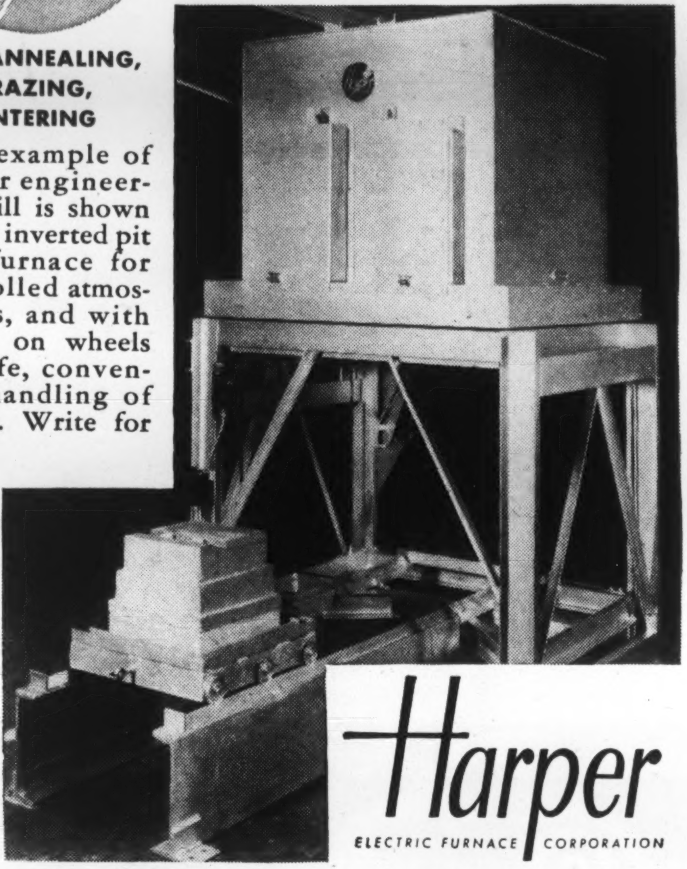

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ELECTRIC FURNACE CORPORATION

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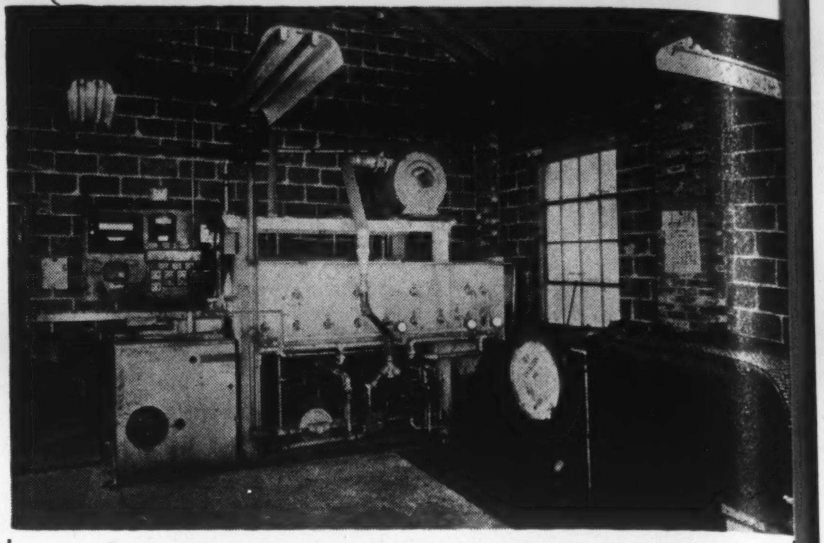

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IN A RECIPROCATING HEATING MACHINE

VERSATILE. Adaptable to a countless variety of work from needles to large forgings. These furnaces may be used for hardening, annealing, normalizing, etc.

SIMPLE. Simply-designed mechanism is out of the heat while the muffle remains in the furnace at all times. Work is in constant motion and so cannot stick to the hearth.

ATMOSPHERE CONTROL. A full muffle is utilized making it possible to maintain a definite atmosphere around the work. This widens the range of usefulness to include clean hardening, carburizing, and "Ni-Carbing".

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American Gas Furnace Co.
Elizabeth, New Jersey

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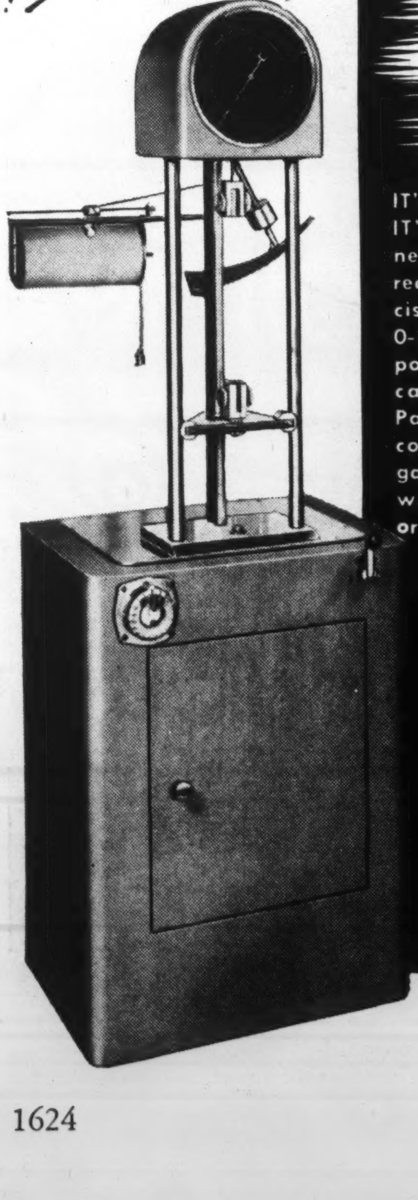

THE NEW Dillon MULTI-LOW RANGE UNIVERSAL TESTER

IT'S ACCURATE! IT'S DIFFERENT! IT'S MODERN! This outstanding new tester has FOUR ranges all reading in ounces for the most precise, analytical work. 0-10 pounds, 0-25 pounds, 0-50 pounds, 0-100 pounds. Pendulum type—actually calibrated with *dead* weights. Packed with new features! Color coded dial, aluminum grips, elongation scale. Completely motorized with *stepless* speed control forward or reverse.

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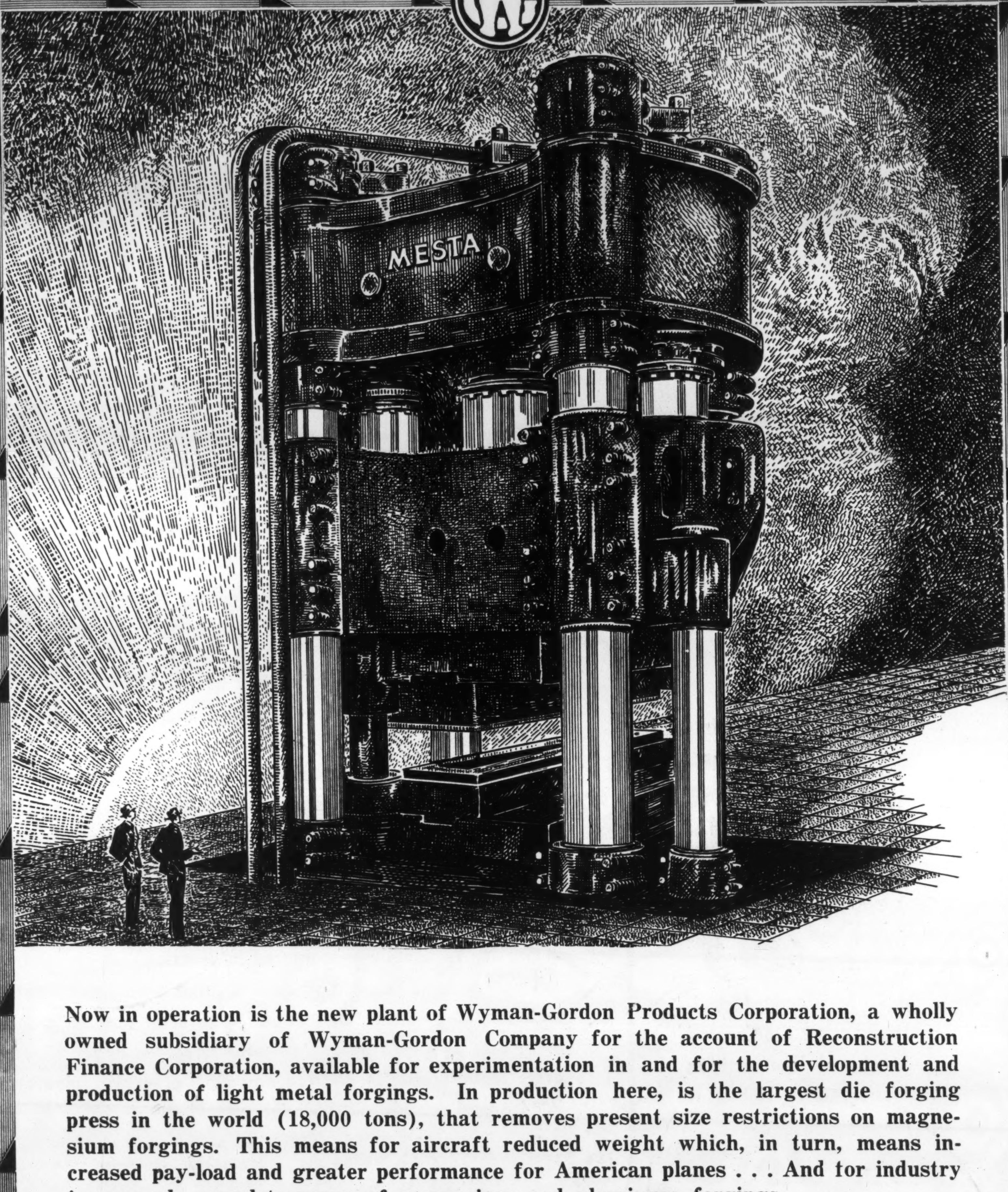

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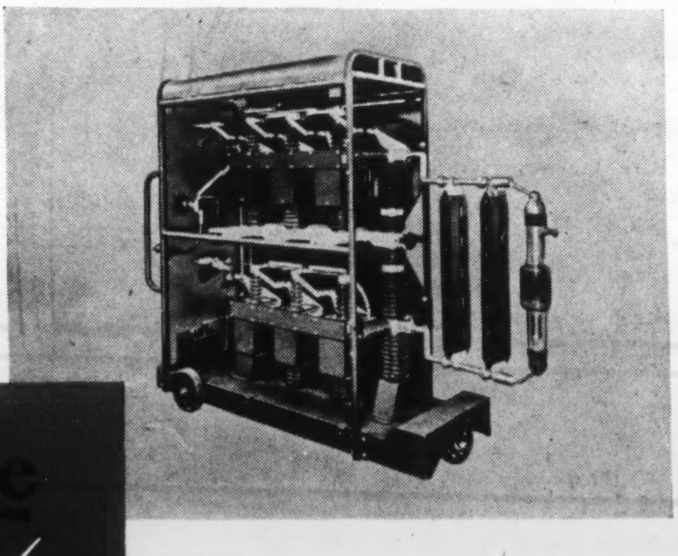

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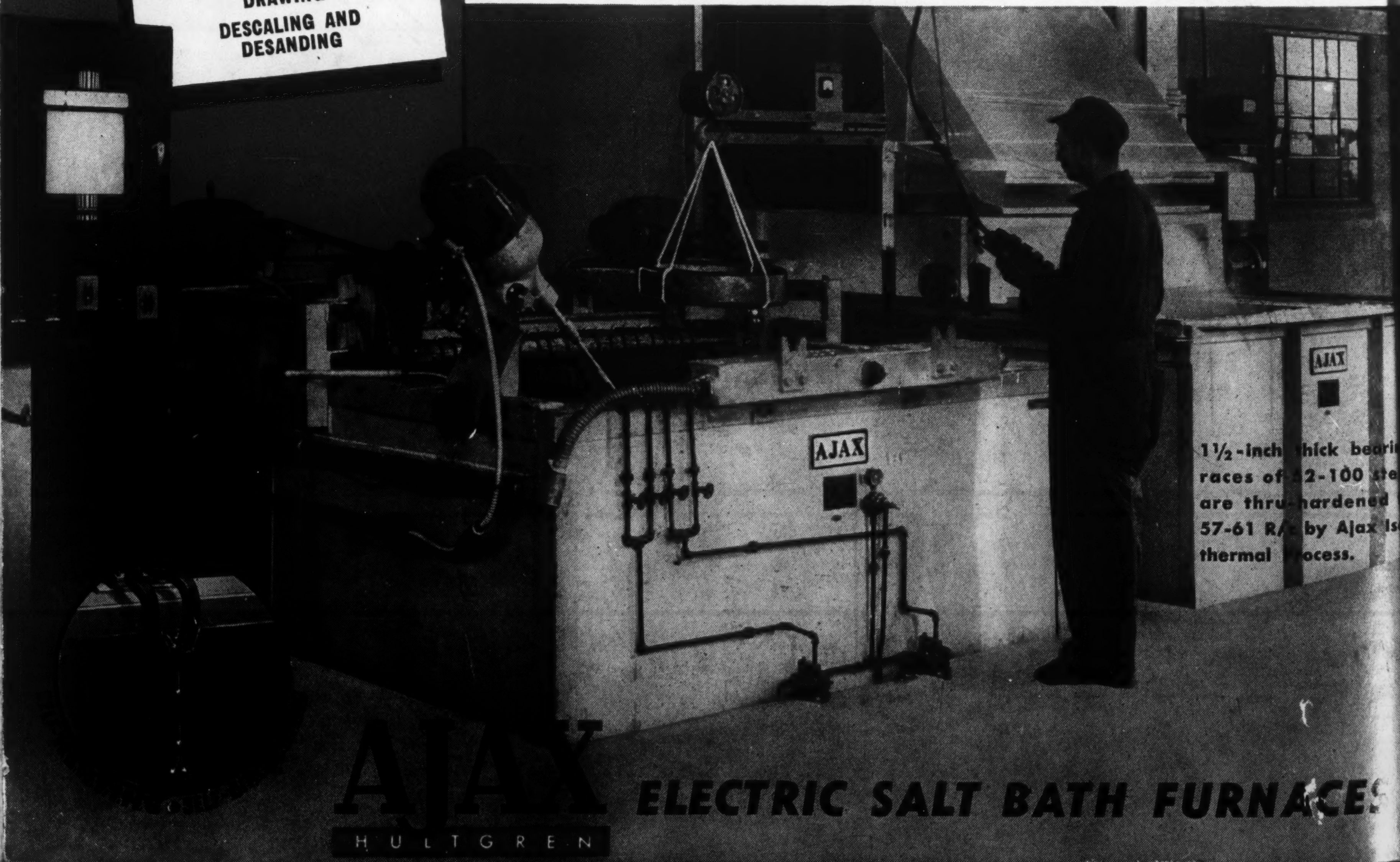

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